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Stumpo et al.

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(54) **HIP ARTHROPLASTY IMPLANTS**

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(22) Filed: **Dec. 4, 2020**

(65) **Prior Publication Data**

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Related U.S. Application Data

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(51) **Int. Cl.**

A61F 2/34 (2006.01)
A61F 2/46 (2006.01)
A61F 2/30 (2006.01)

(52) **U.S. Cl.**

CPC ***A61F 2/34*** (2013.01); ***A61F 2/4609*** (2013.01); *A61F 2002/30112* (2013.01); *A61F 2002/30154* (2013.01); *A61F 2002/30505* (2013.01); *A61F 2002/3417* (2013.01); *A61F 2002/4629* (2013.01); *A61F 2002/4681* (2013.01)

(58) **Field of Classification Search**

CPC A61F 2/34; A61F 2/4609; A61B 17/56; A61B 17/58; A61B 17/88; A61B 17/8872; A61B 17/92; A61B 17/1746

See application file for complete search history.

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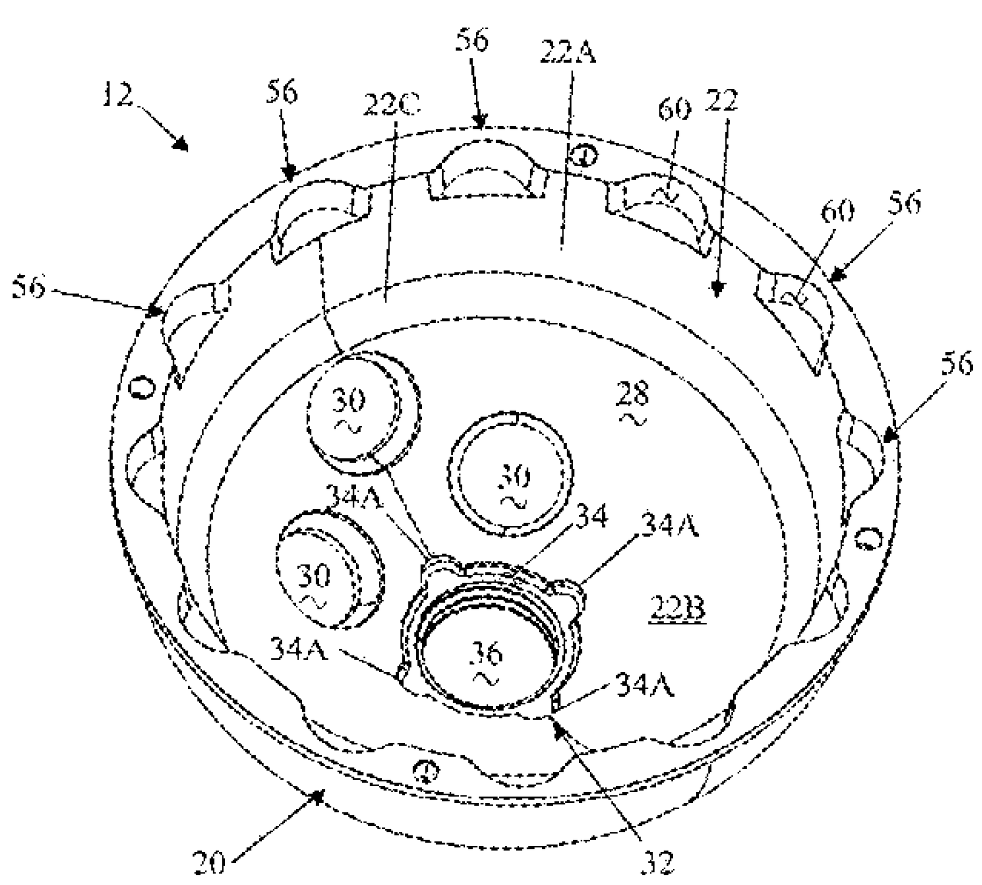
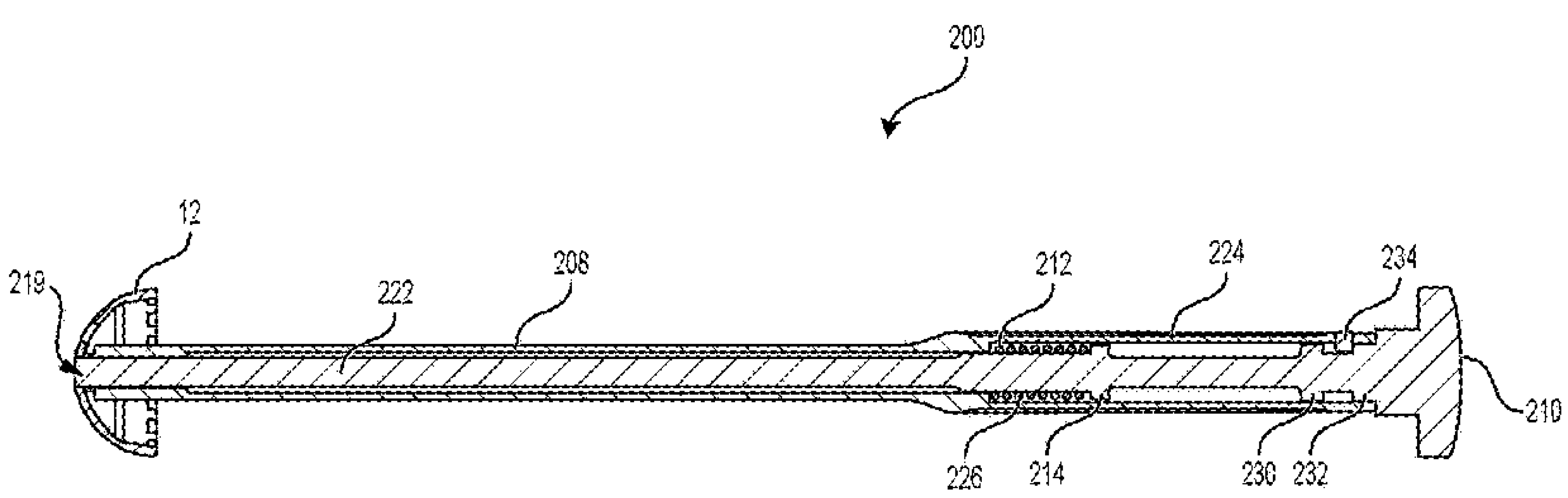
Primary Examiner — Brian A Dukert

(57) **ABSTRACT**

An acetabular shell insertion tool with an anti-rotation feature is provided. The insertion tool attaches to an acetabular shell including a center hole having an internal threading and an anti-rotation recess disposed around the center hole and having a predetermined shape. The insertion tool includes an outer shaft and an inner shaft disposed within the outer shaft. The outer shaft has an anti-rotation projection shaped to be received in the anti-rotation recess of the acetabular shell so as to prevent rotation of the outer shaft relative to the acetabular shell, thereby preventing the insertion tool from disengaging from the shell. The inner shaft has a threaded tip adapted to be threaded into the internal threading of the center hole to lock the insertion tool to the acetabular shell.

19 Claims, 15 Drawing Sheets





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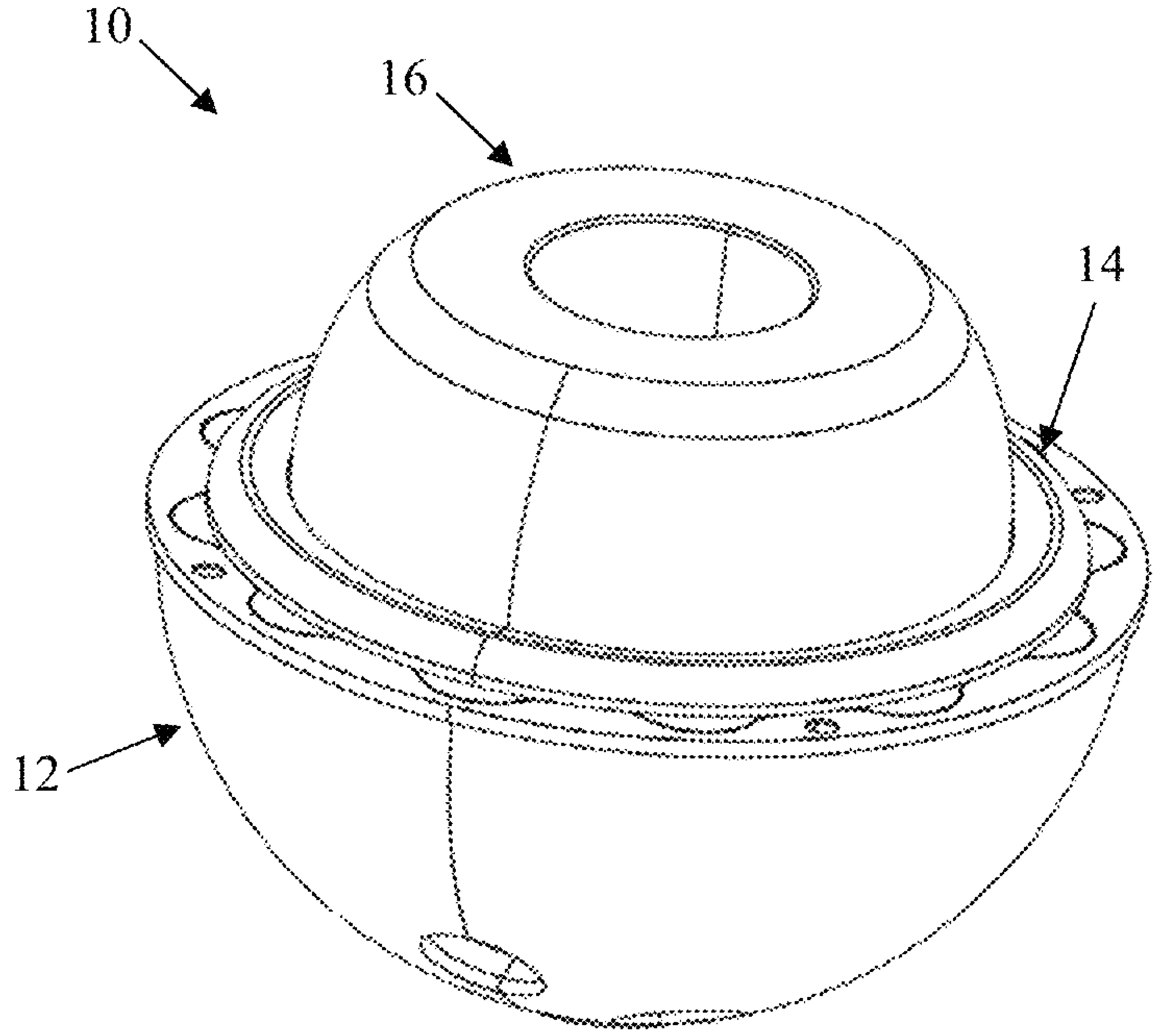


FIG. 1

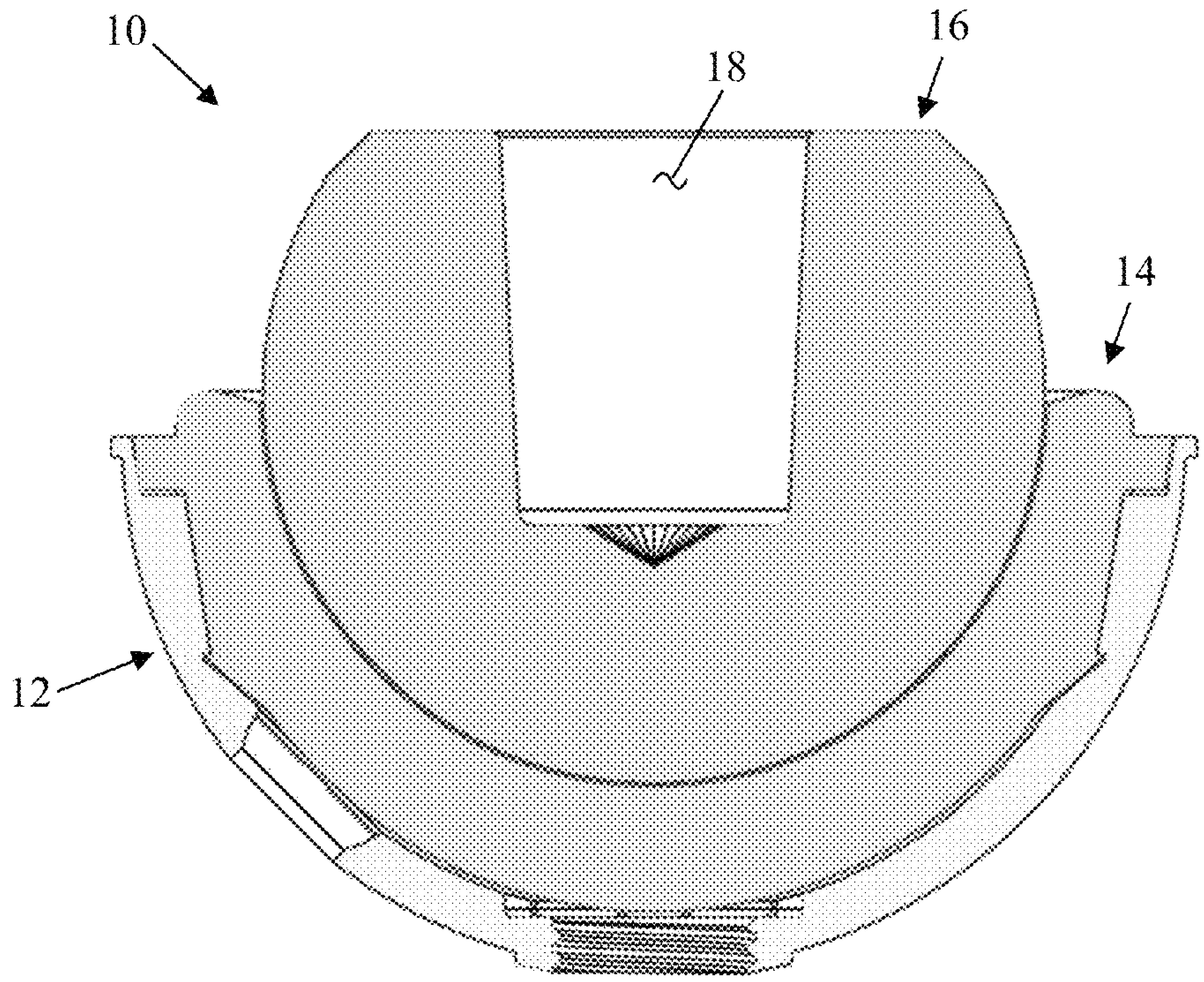
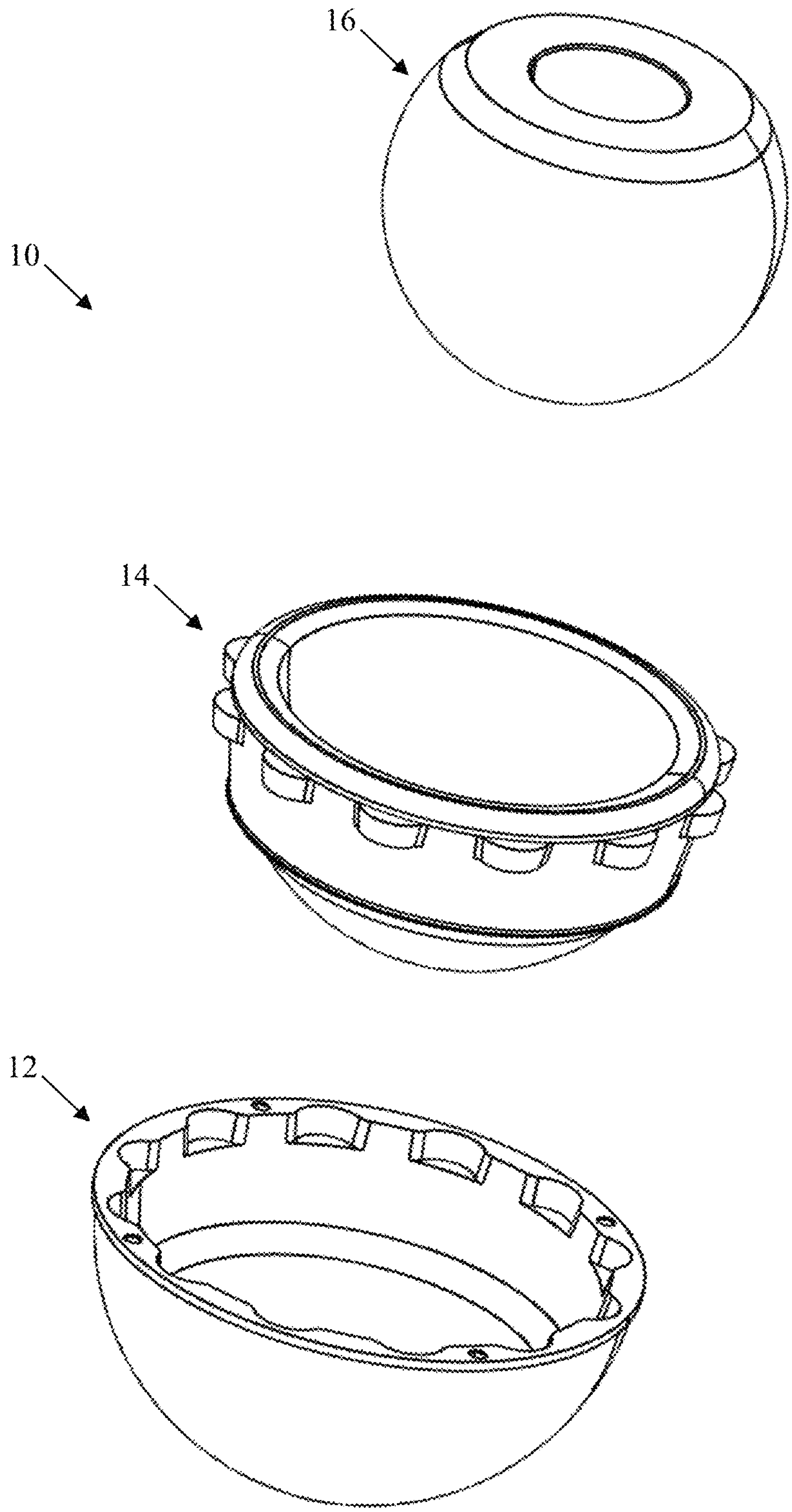


FIG. 2



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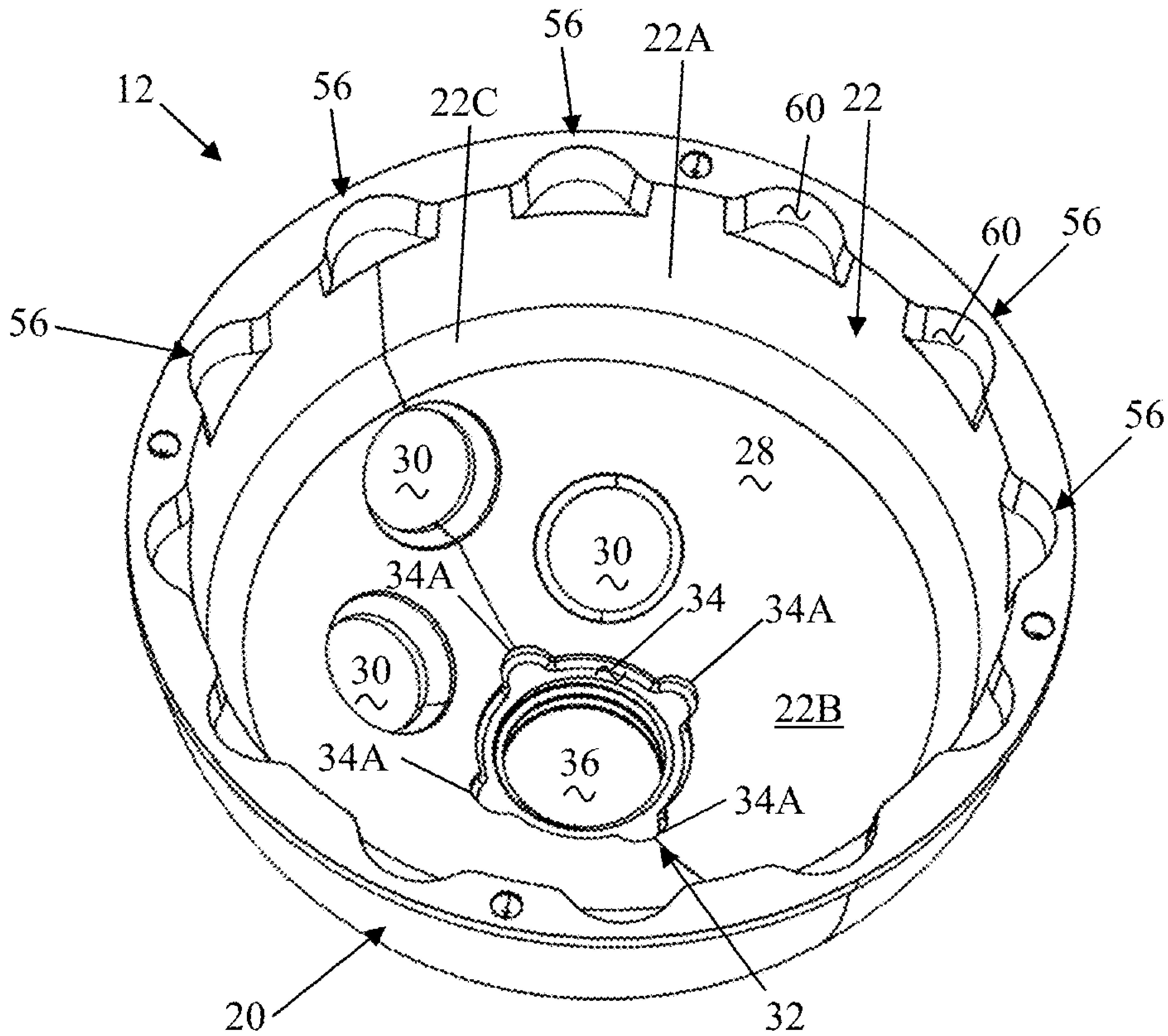
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FIG. 4

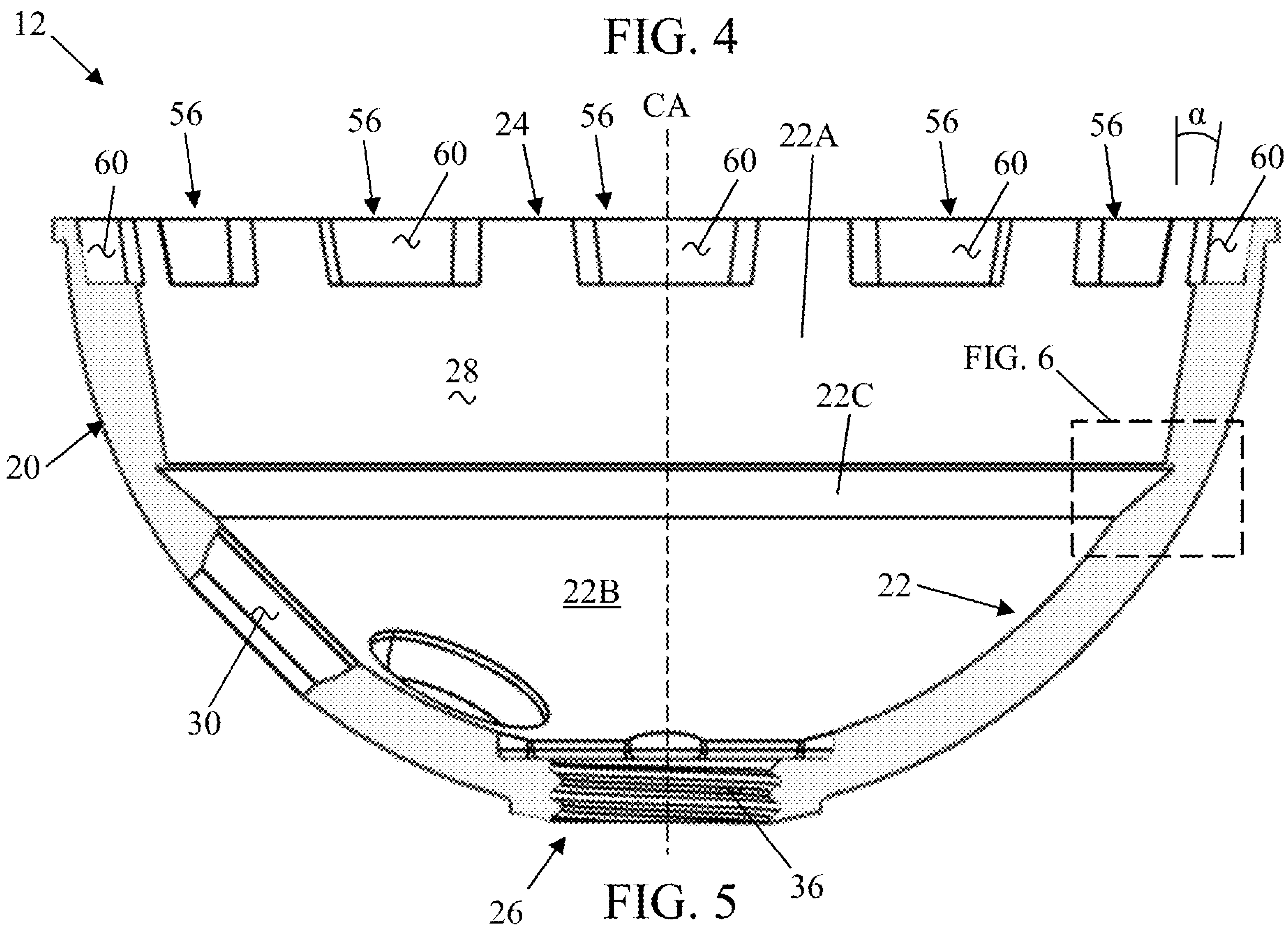
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FIG. 6
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22B
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FIG. 5

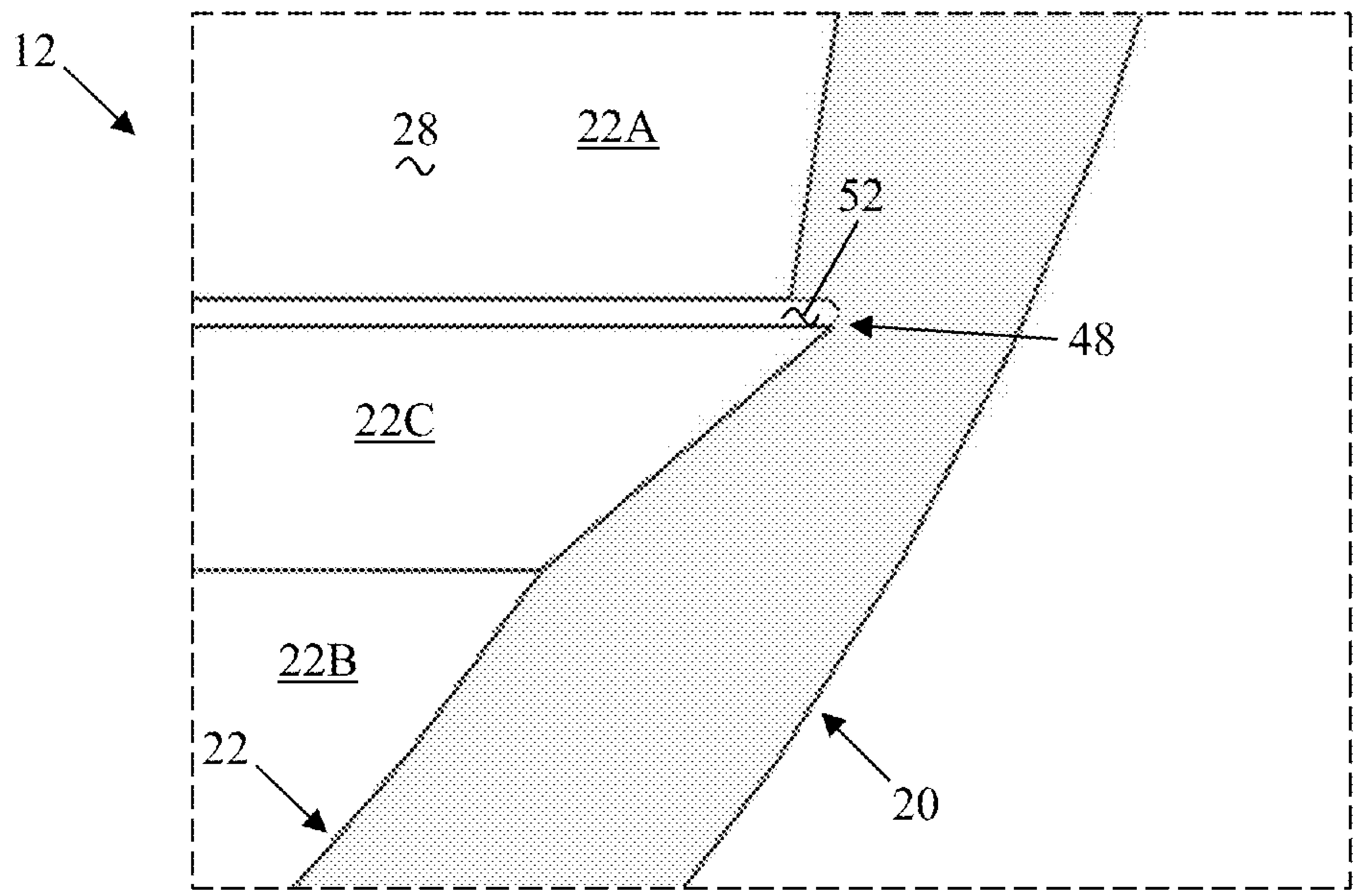
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FIG. 6

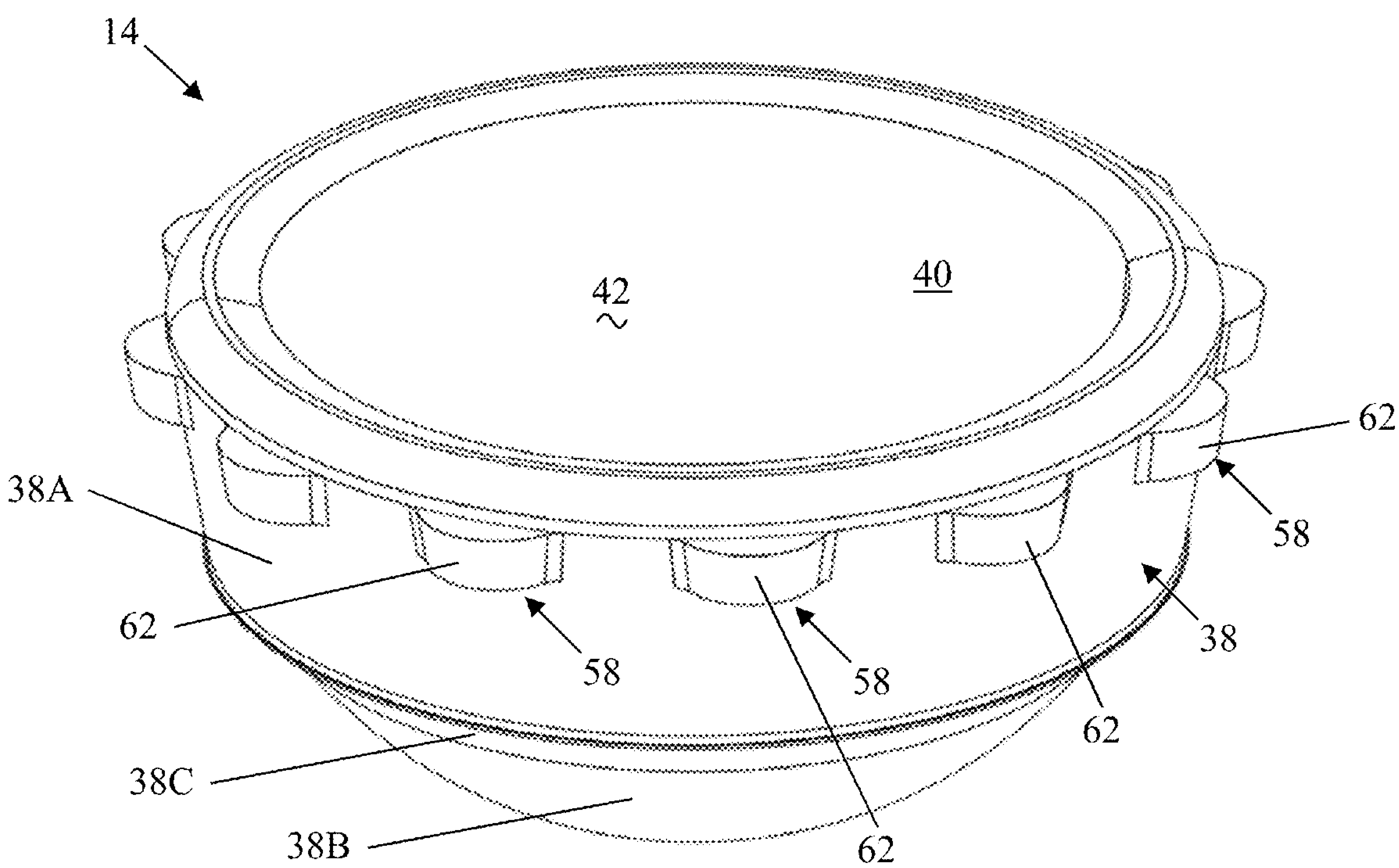
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FIG. 7

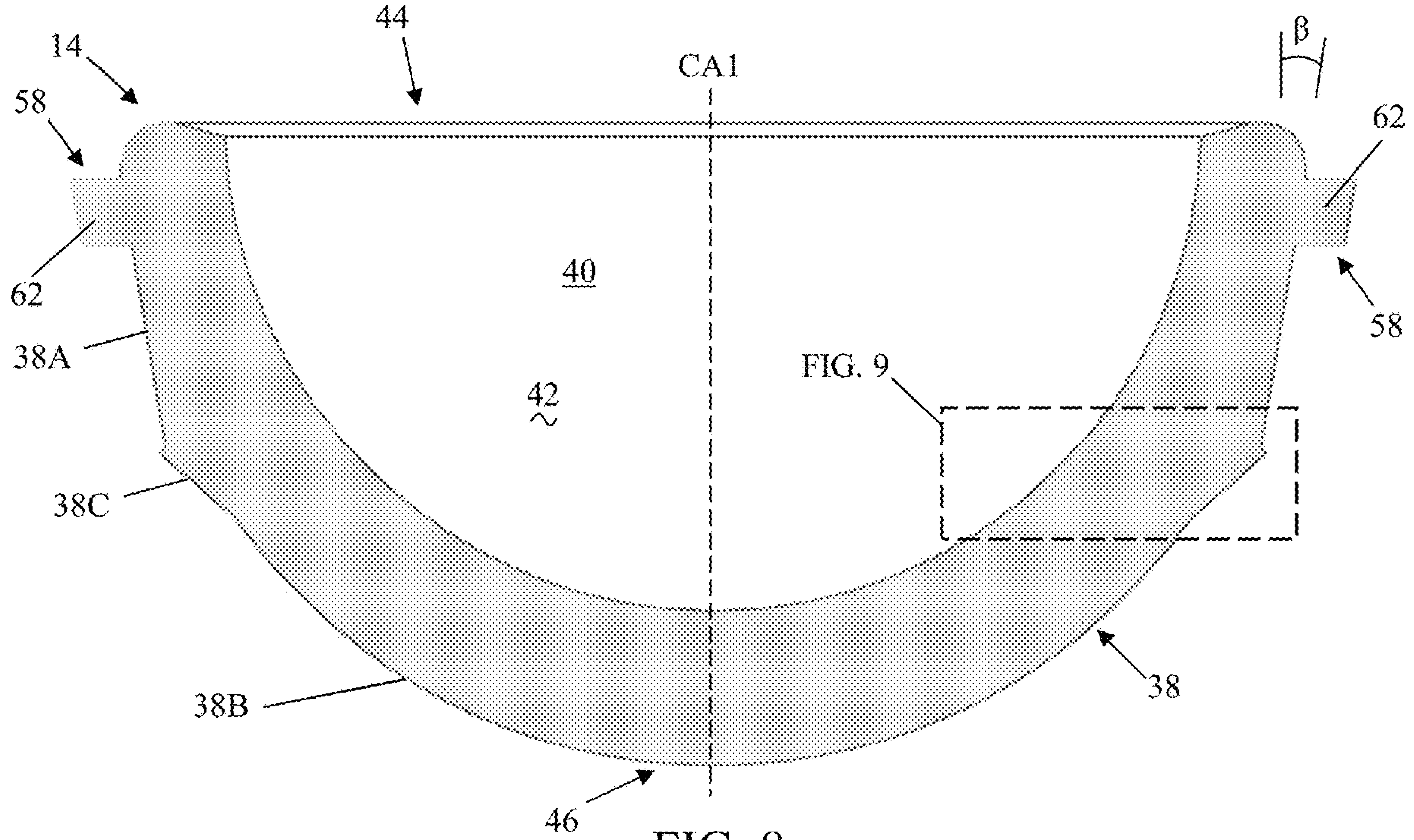
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FIG. 9
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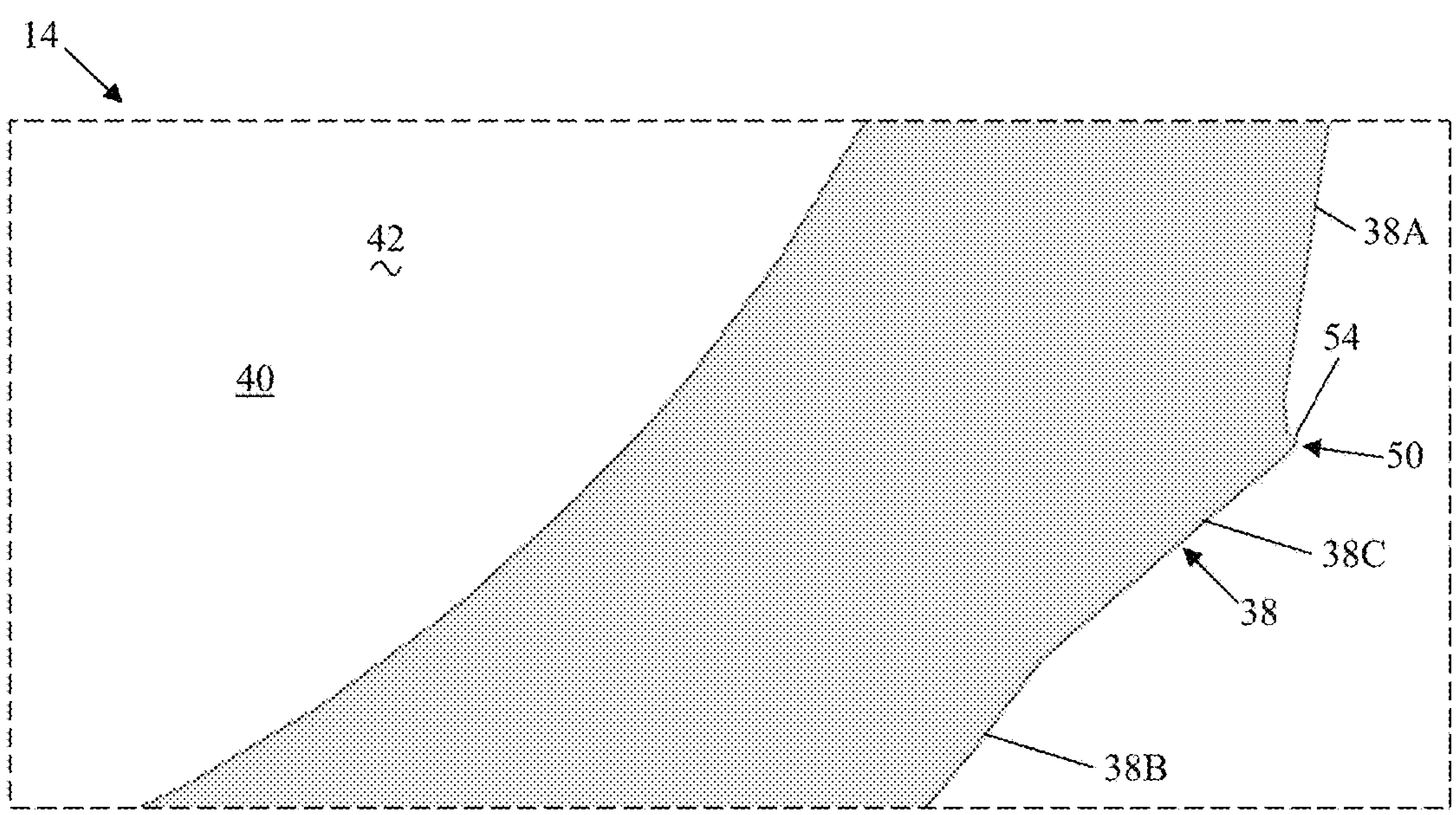
FIG. 8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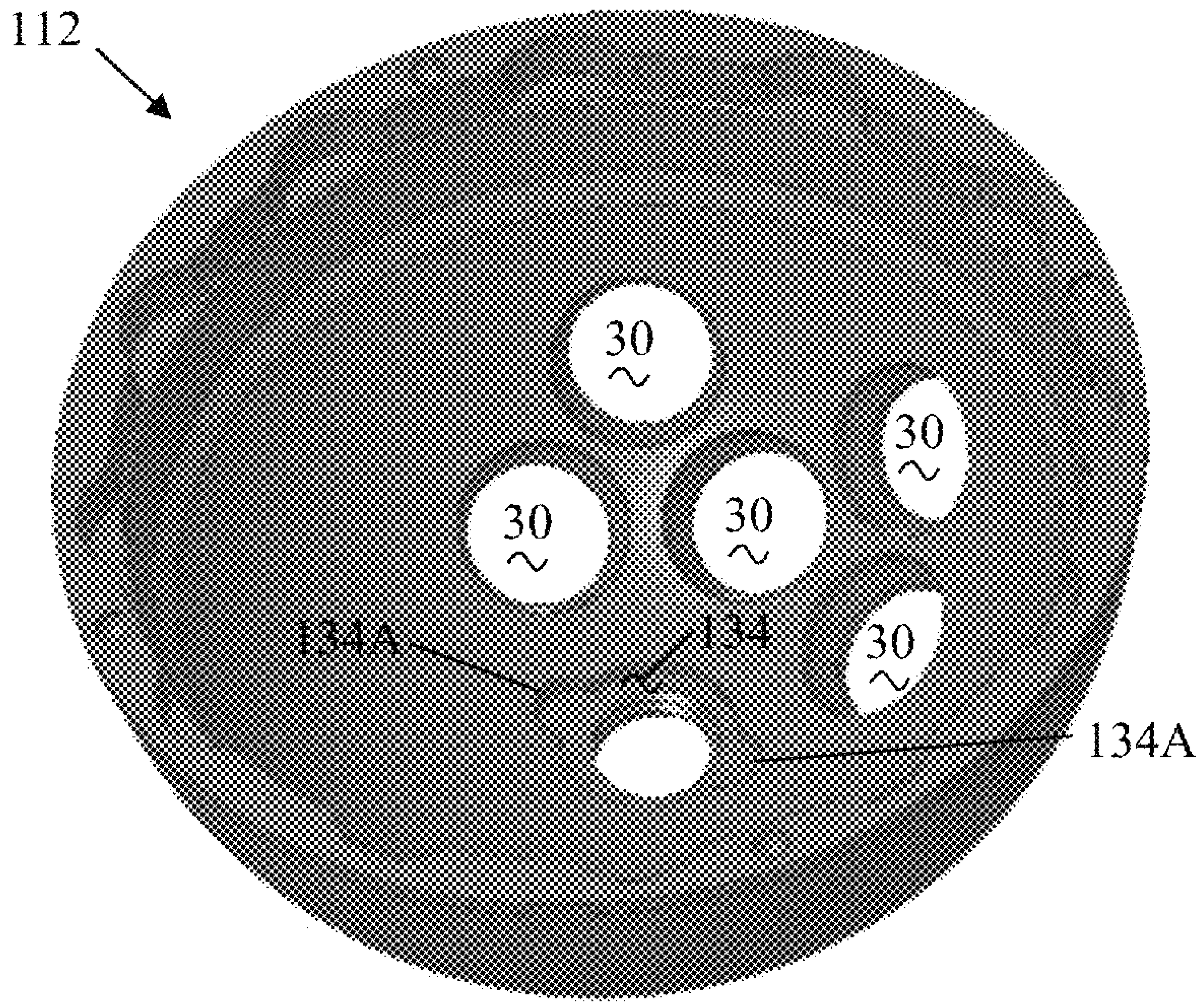
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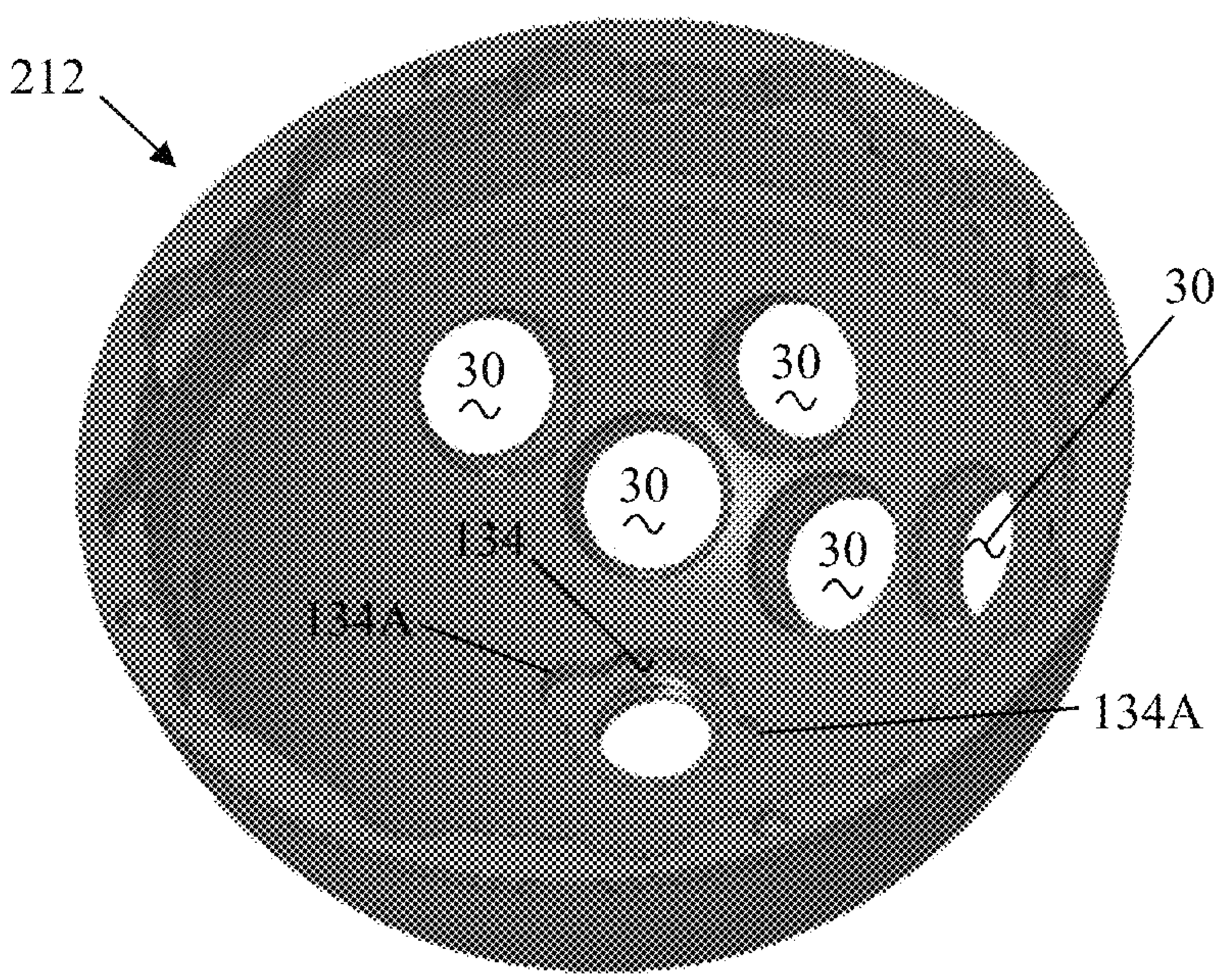
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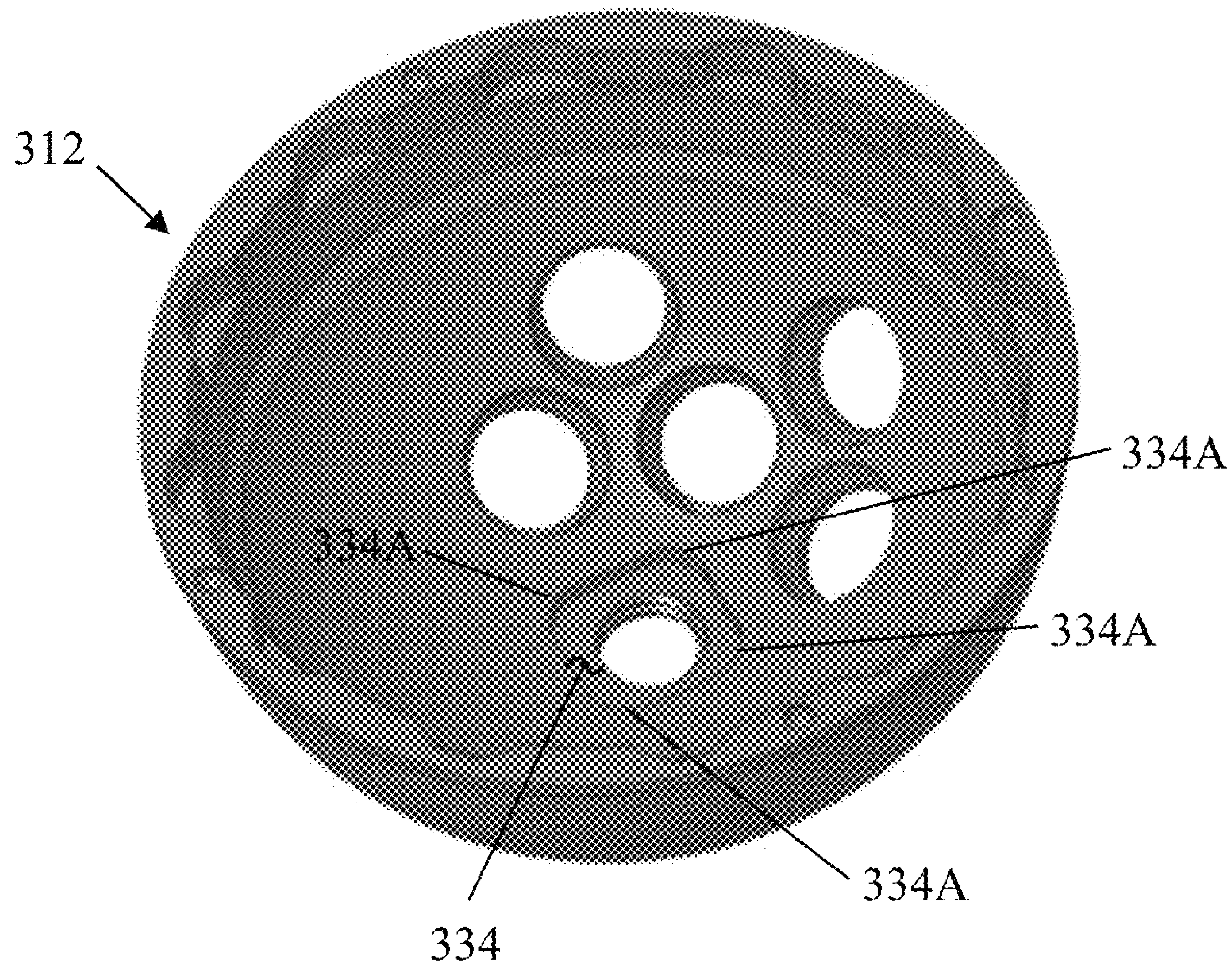

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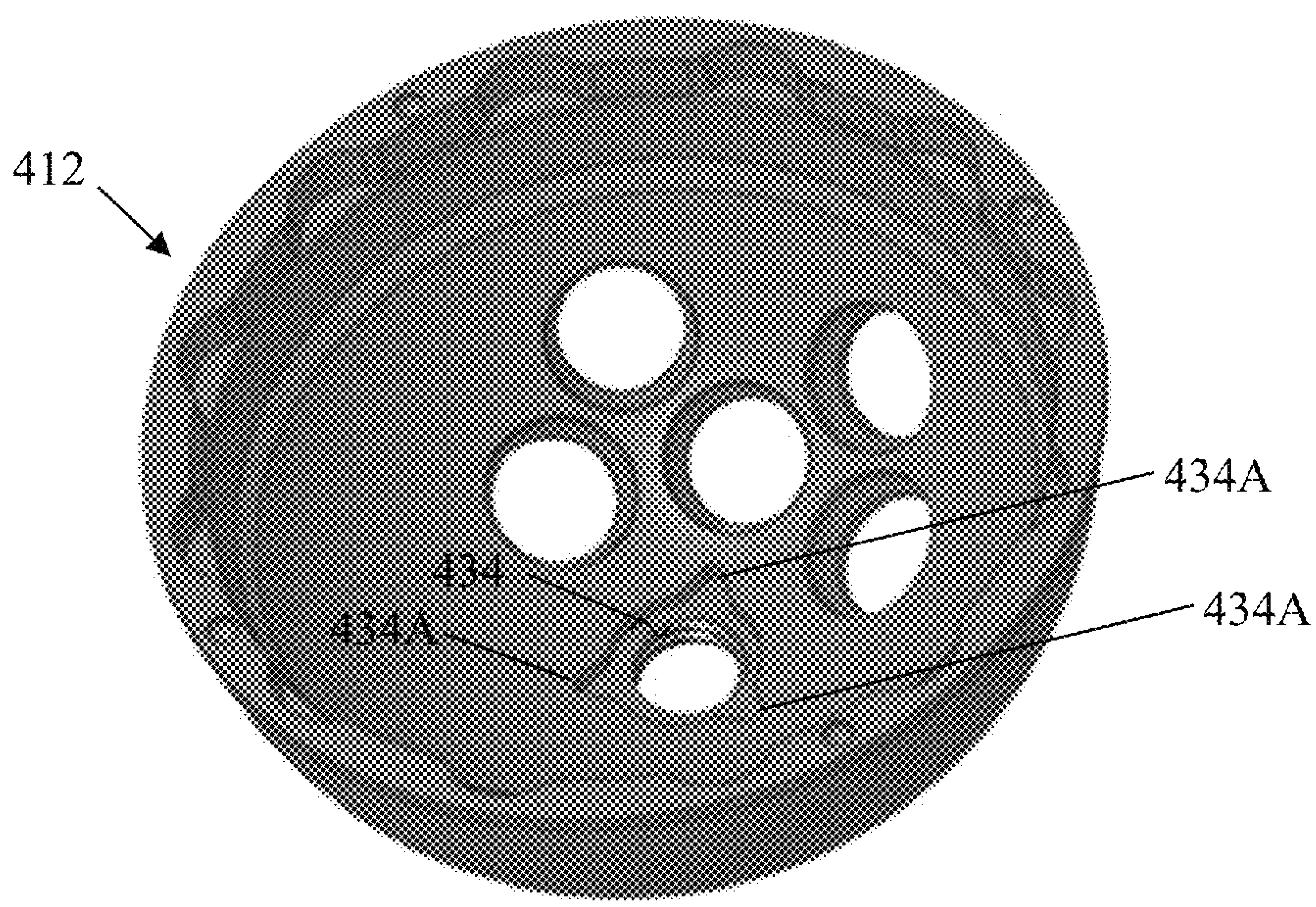


FIG. 13

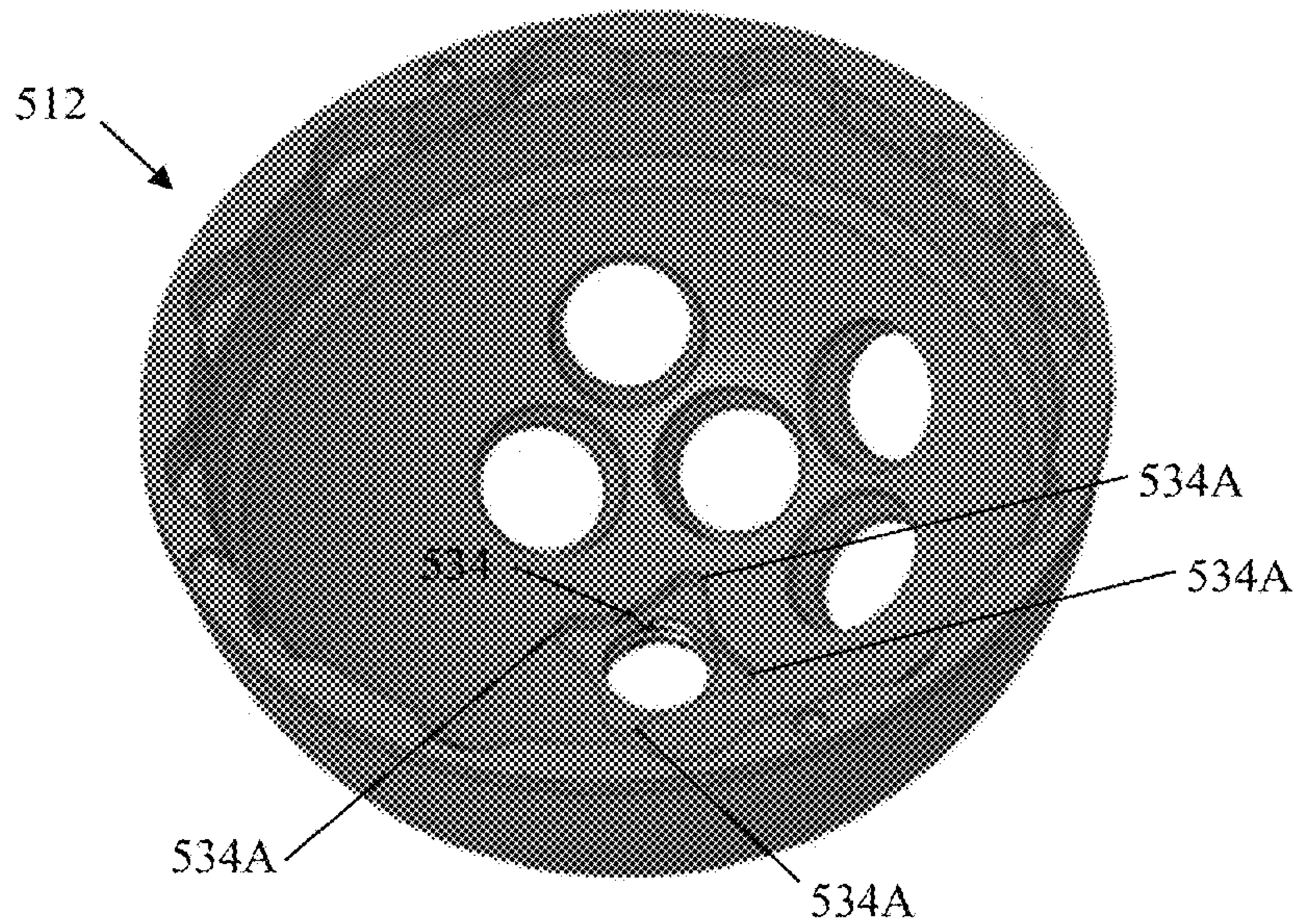


FIG. 14

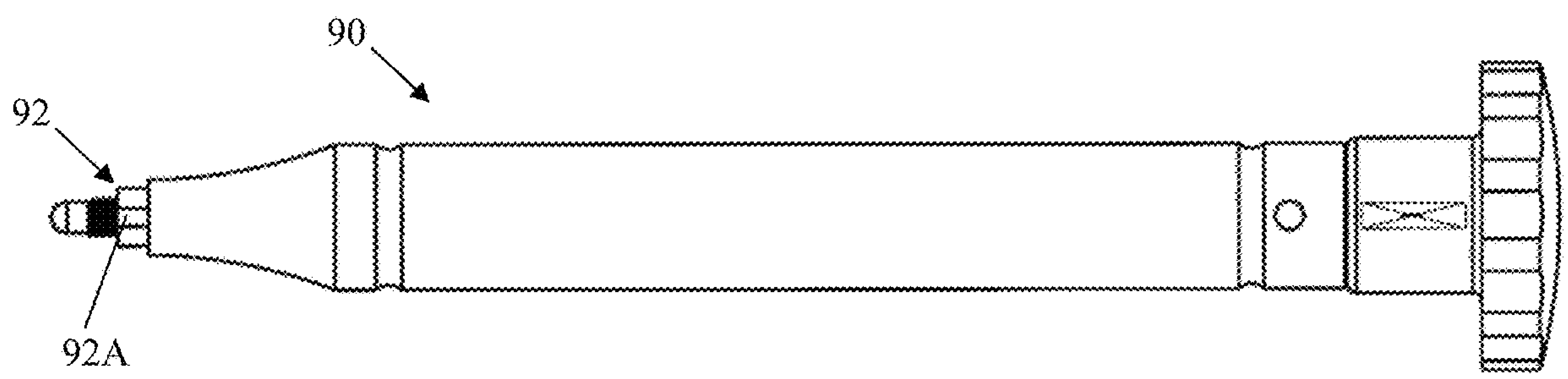


FIG. 15

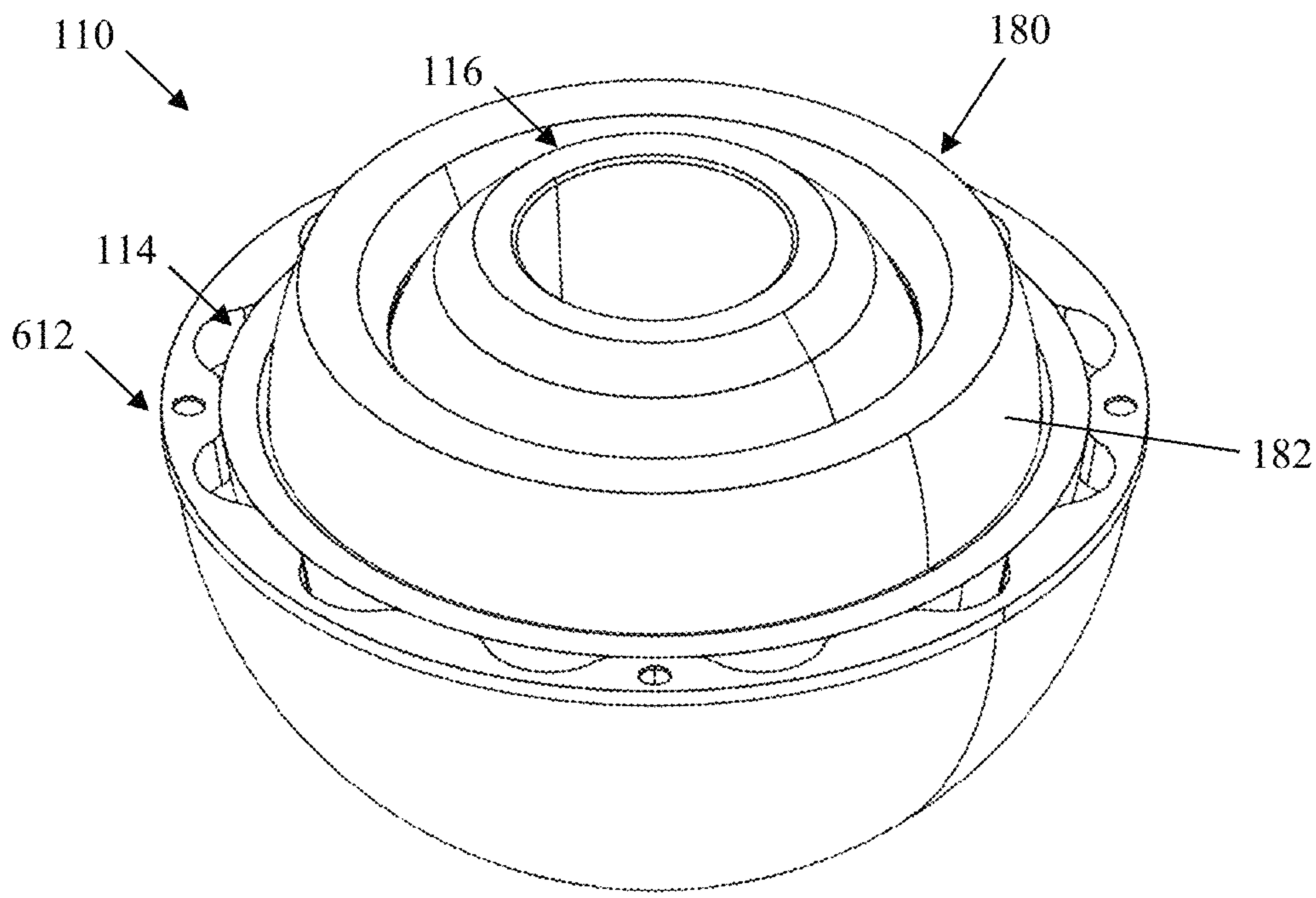


FIG. 16

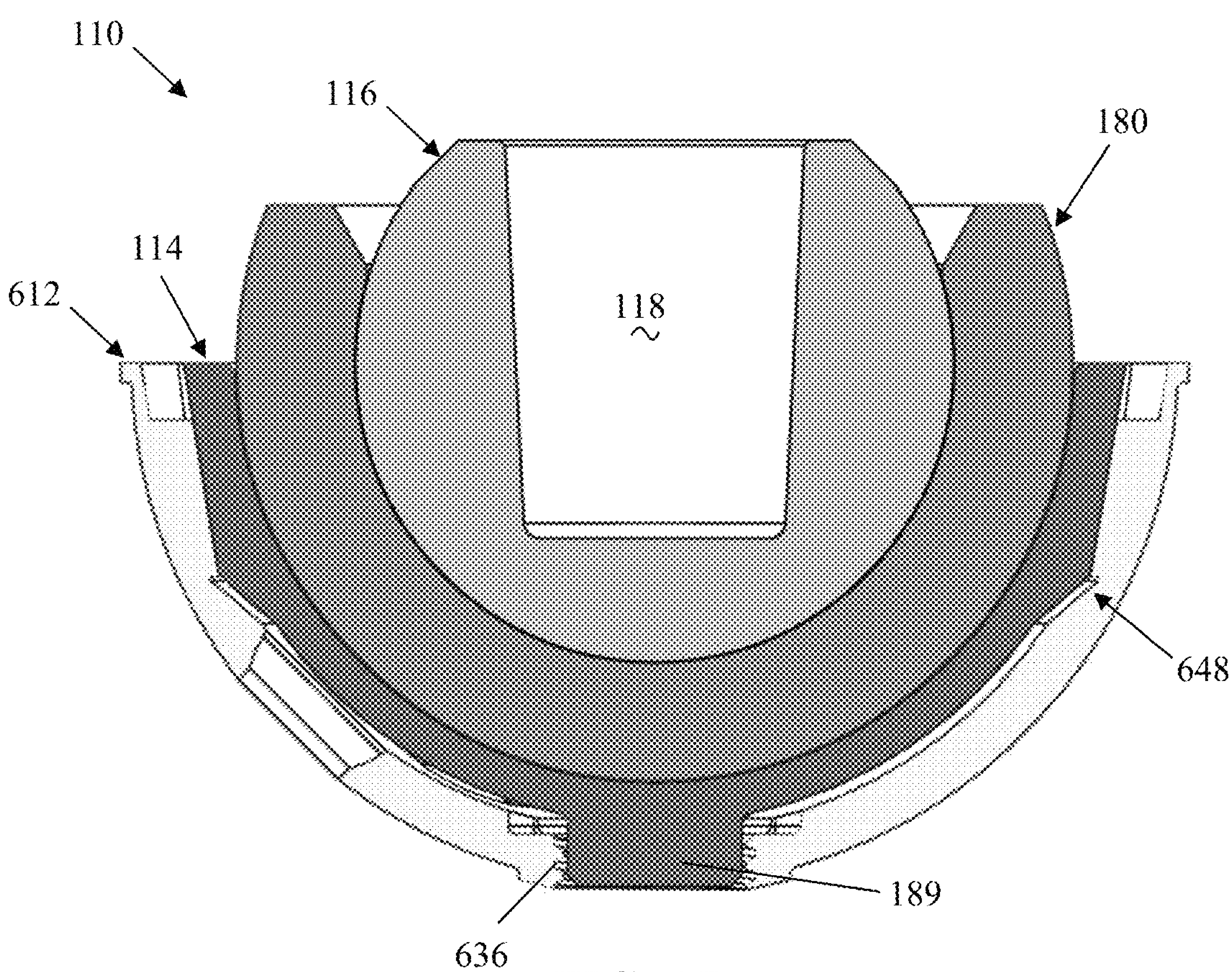


FIG. 17

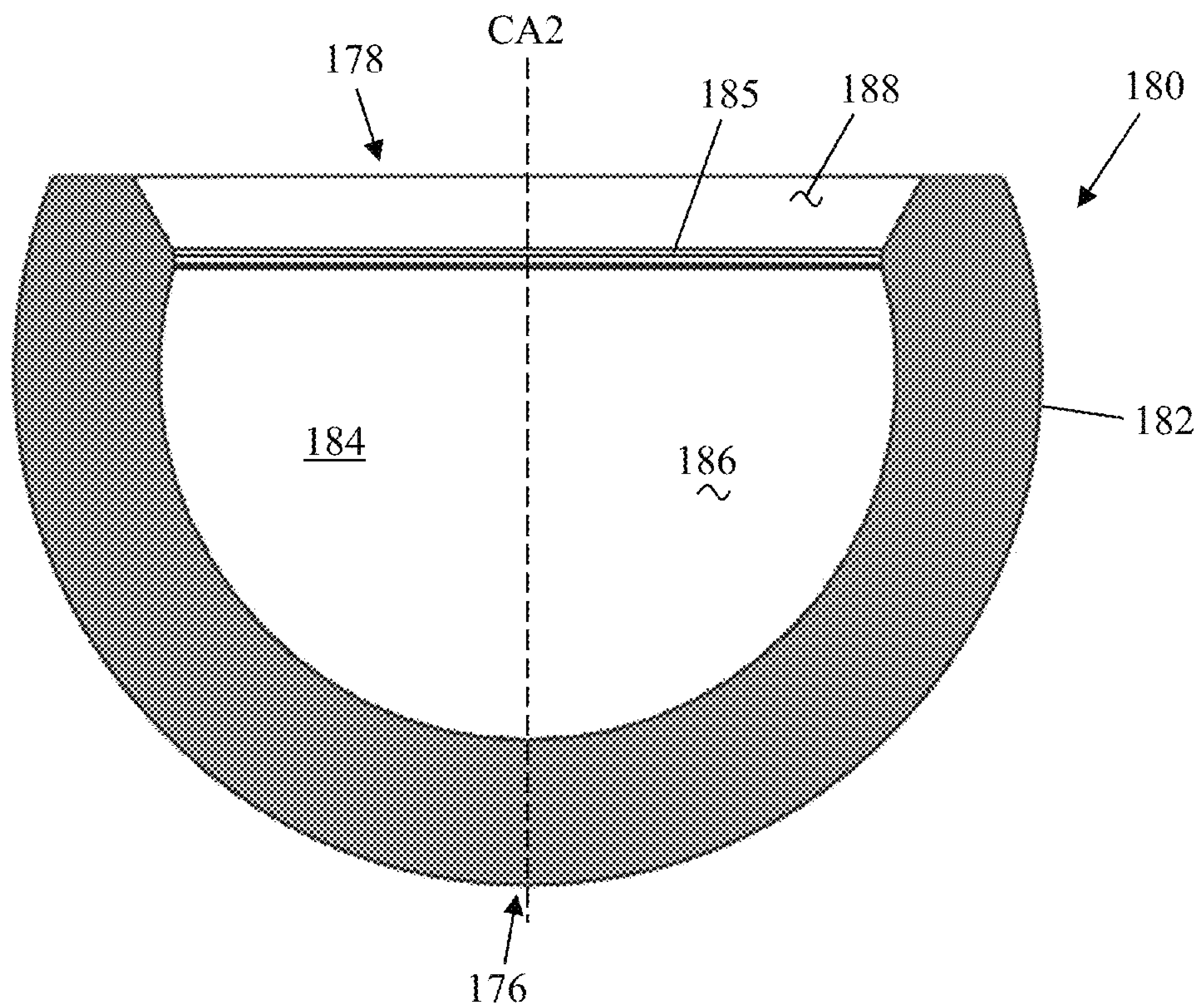


FIG. 18

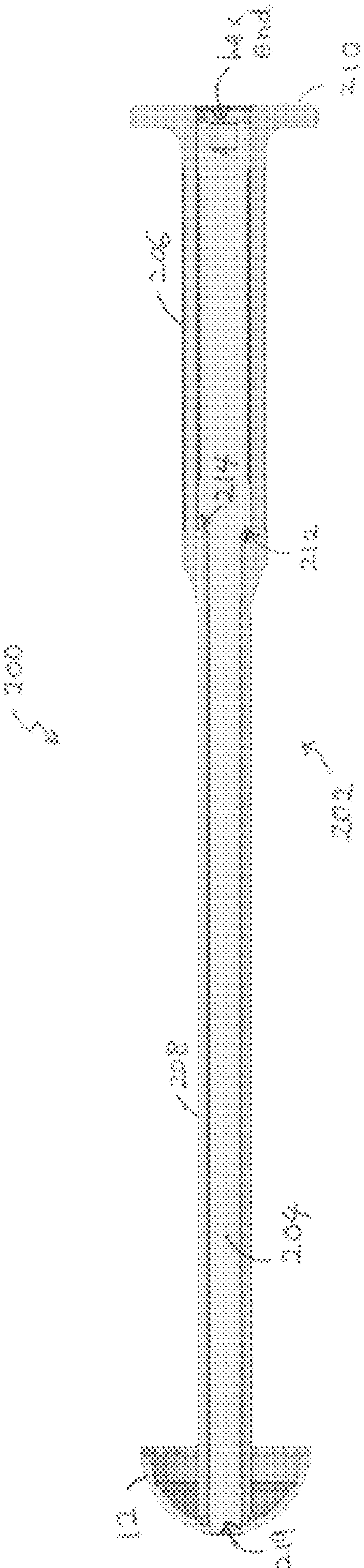


FIG. 19A

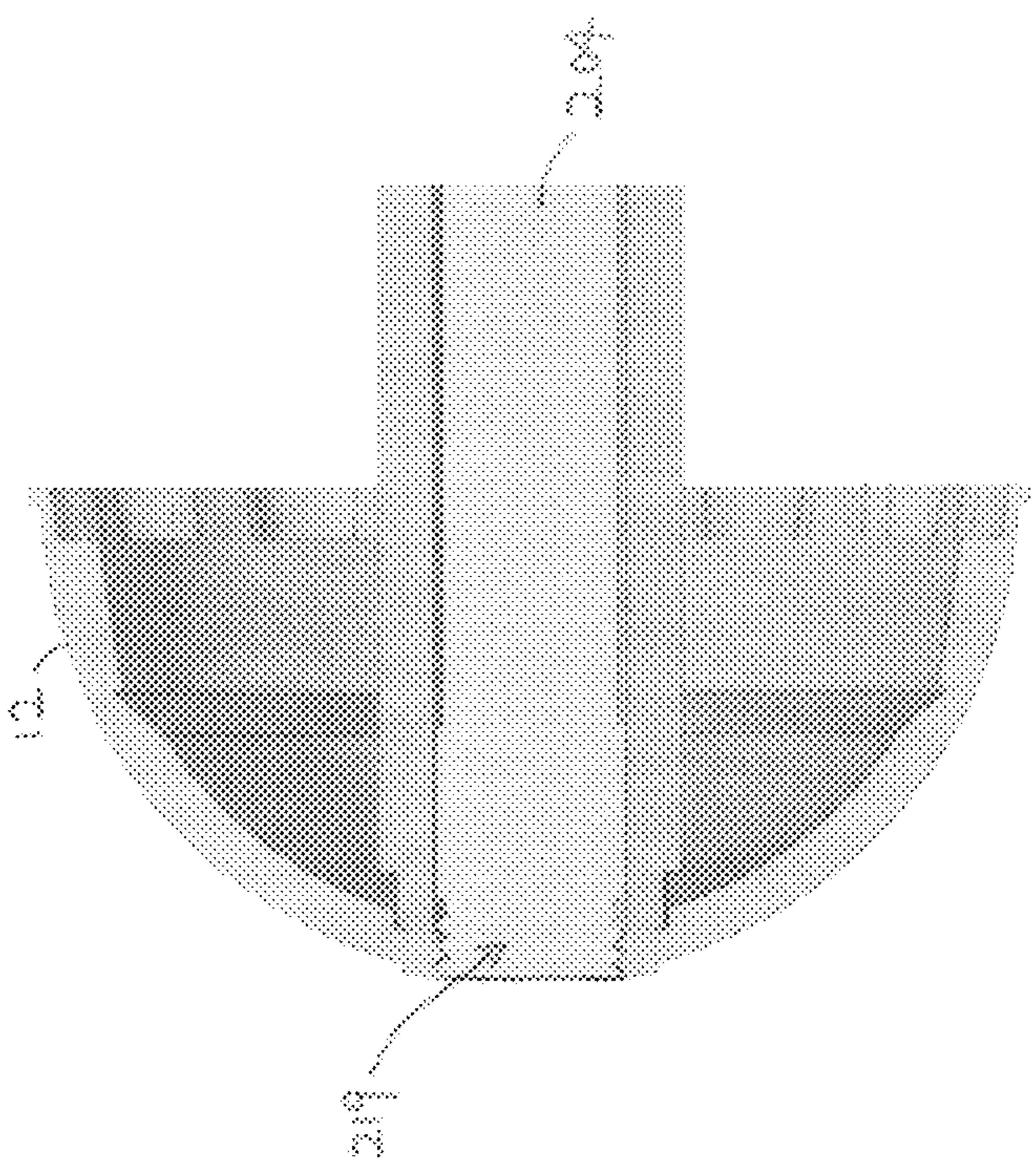


FIG. 19B

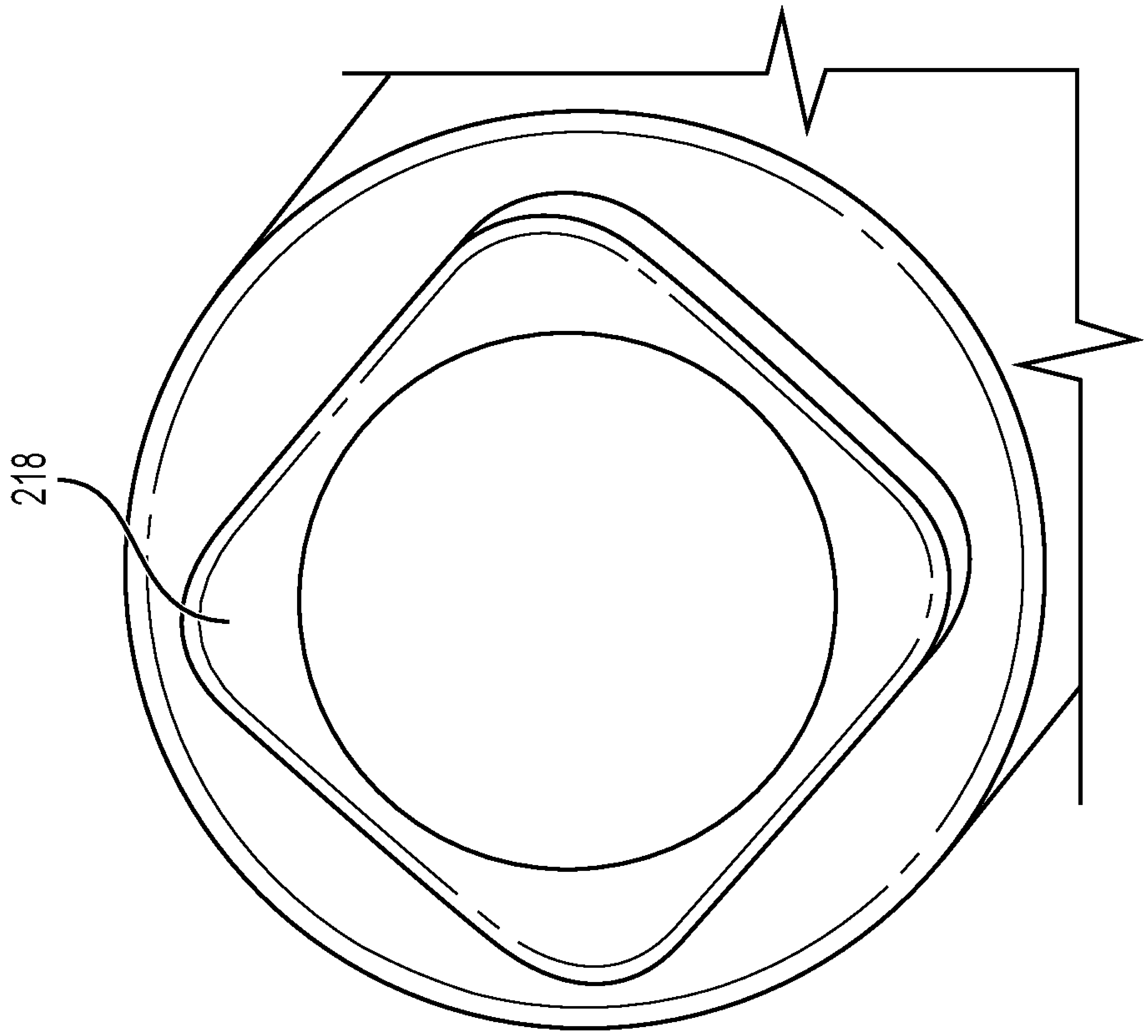


FIG. 20B

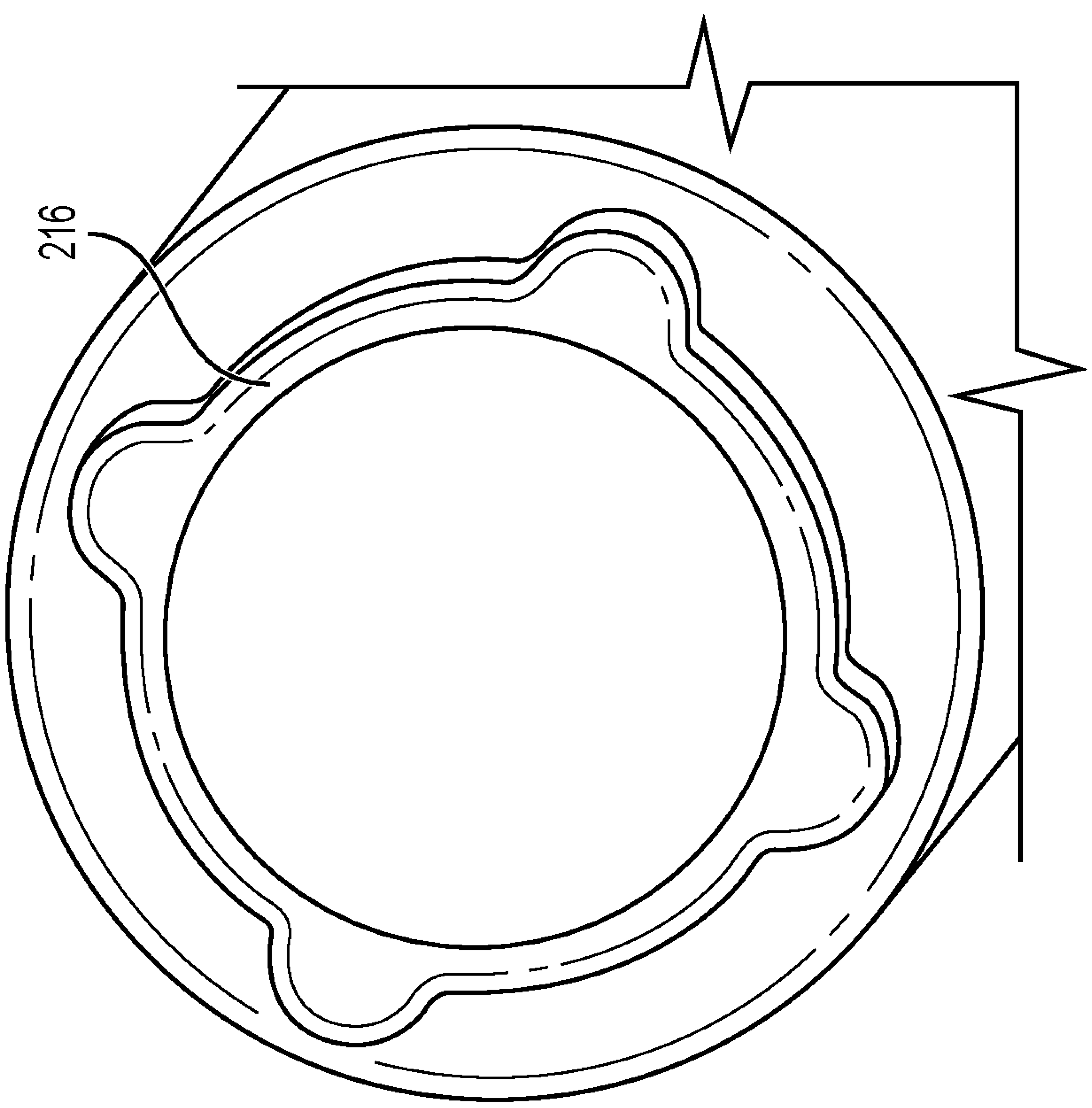


FIG. 20A

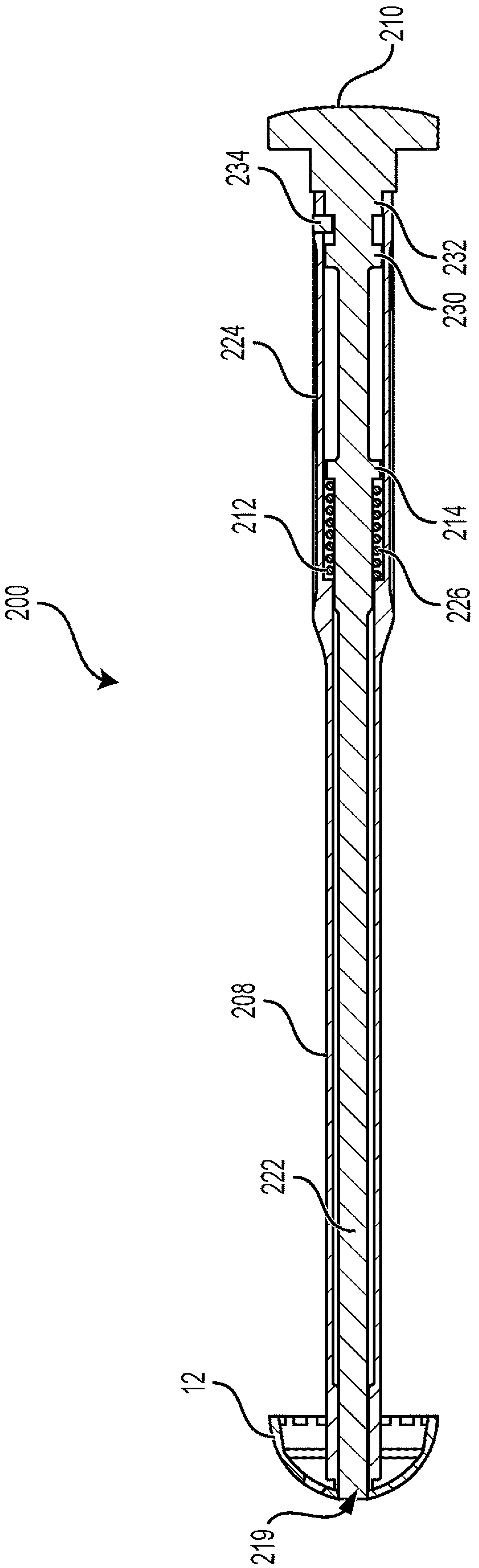


FIG. 21

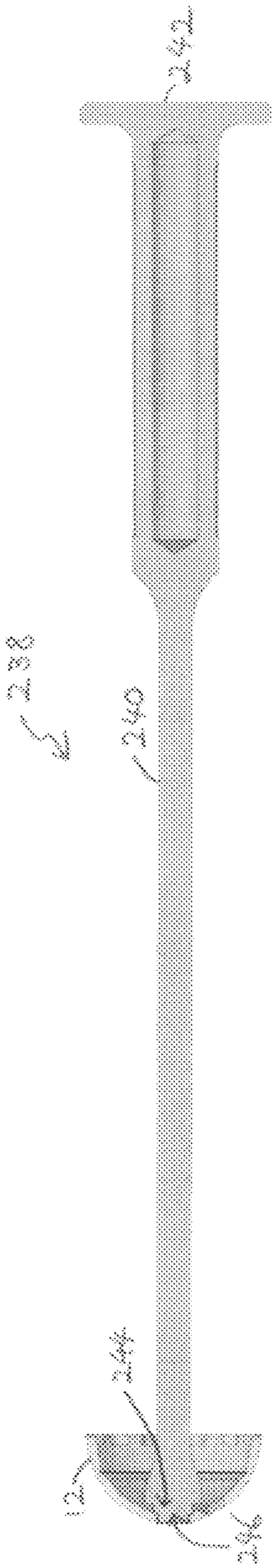
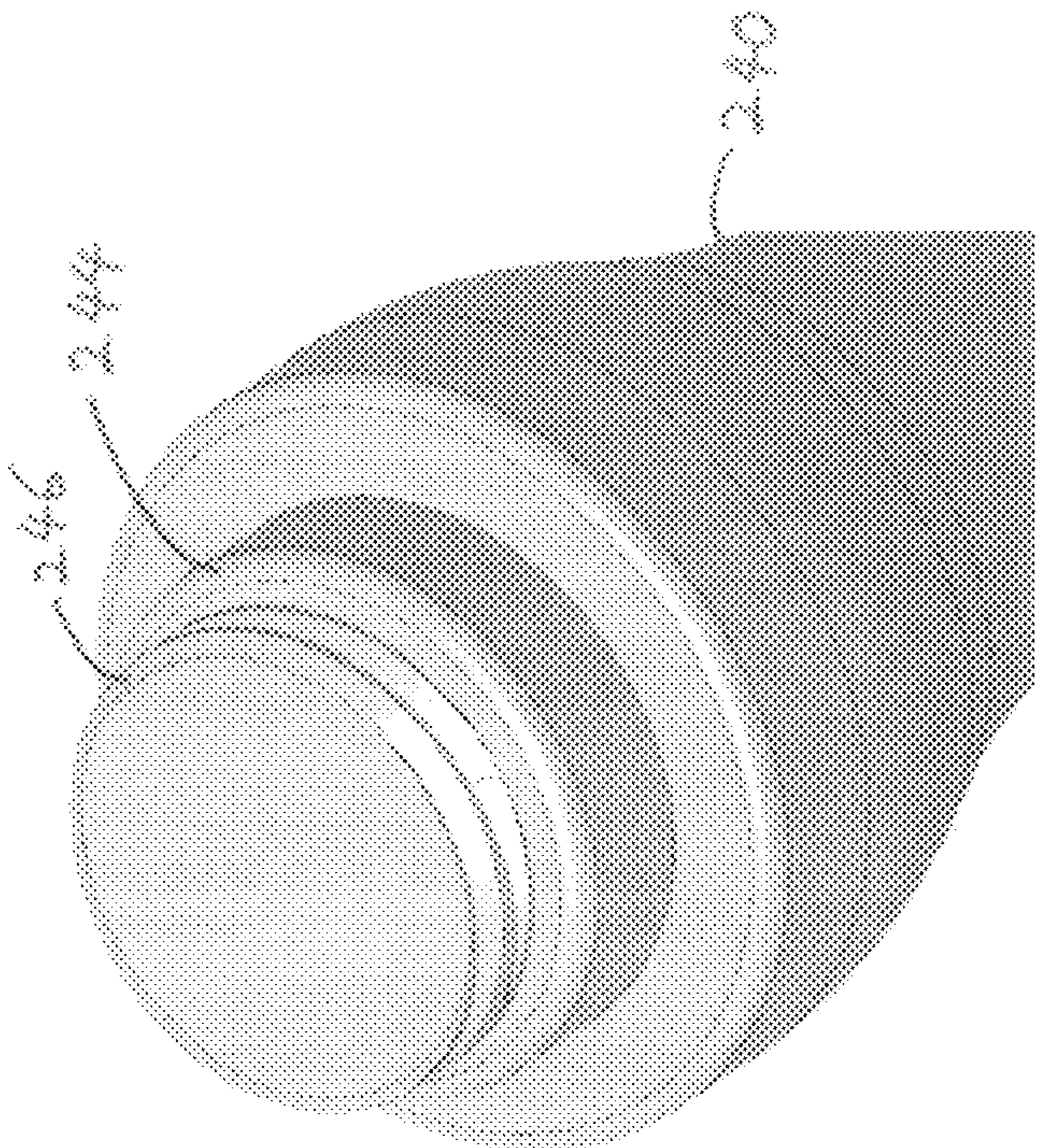


FIG. 22A



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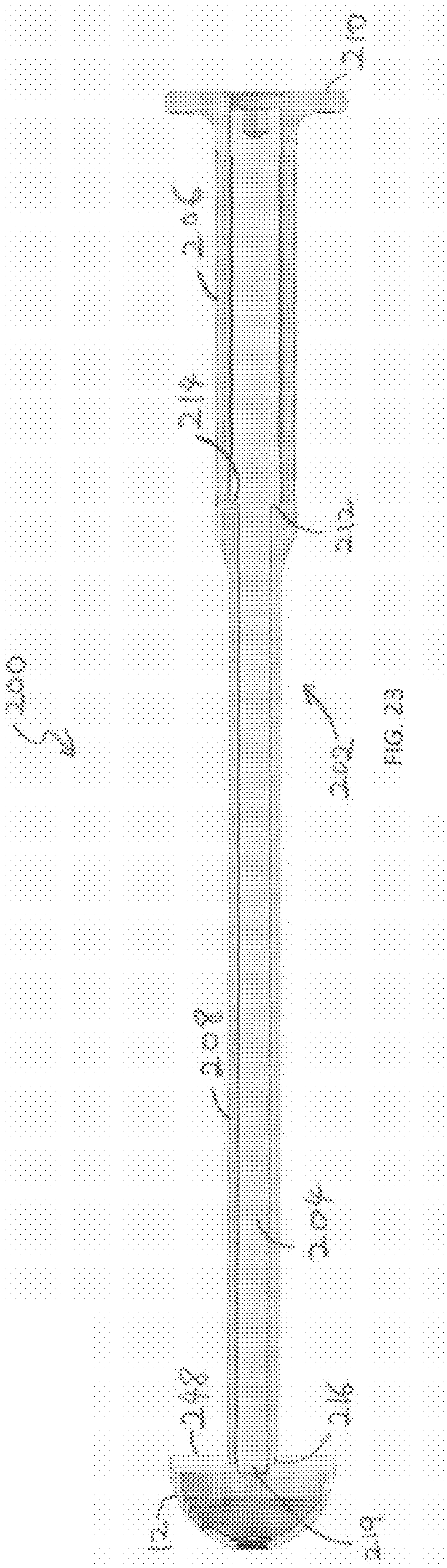

FIG. 23

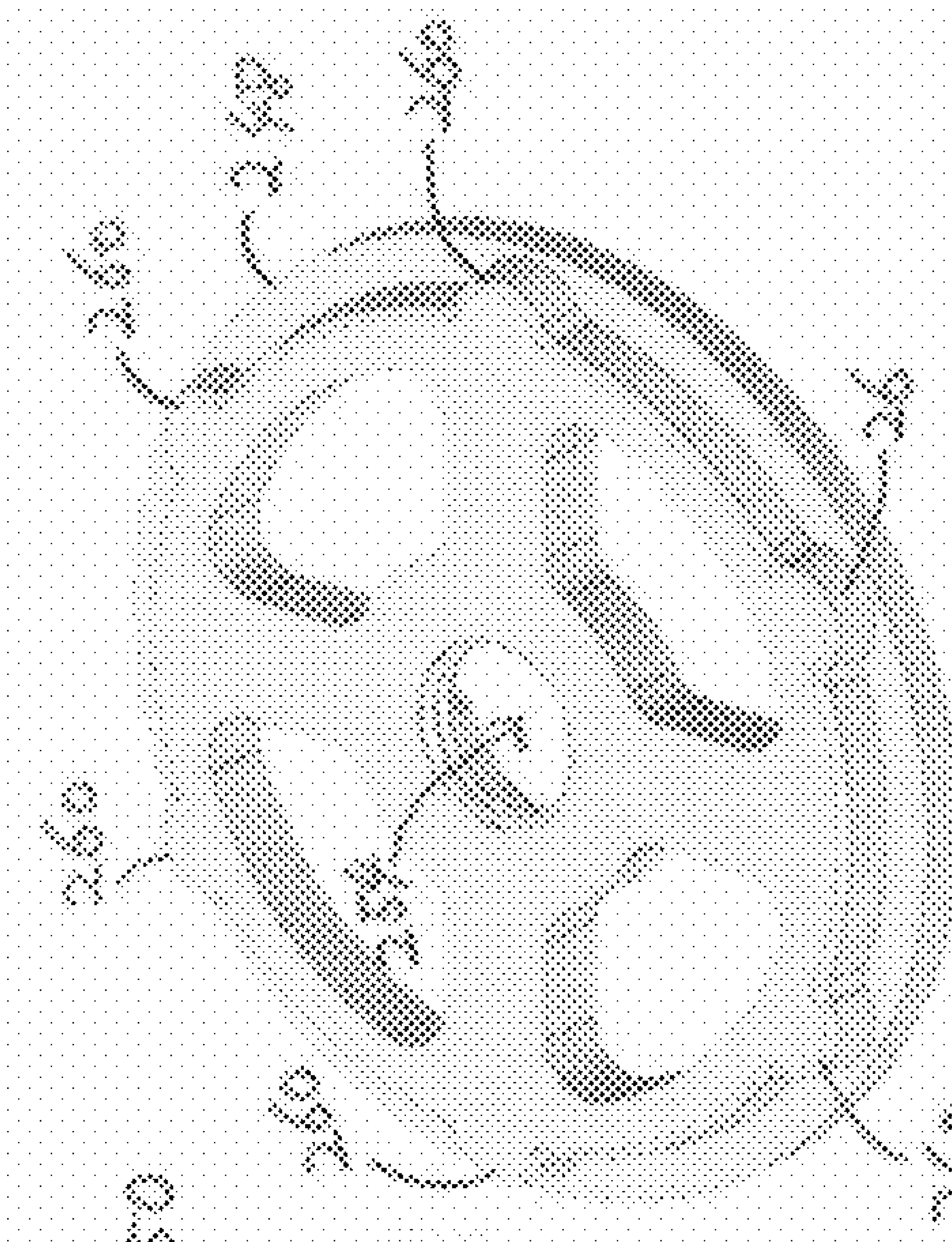

FIG. 24C

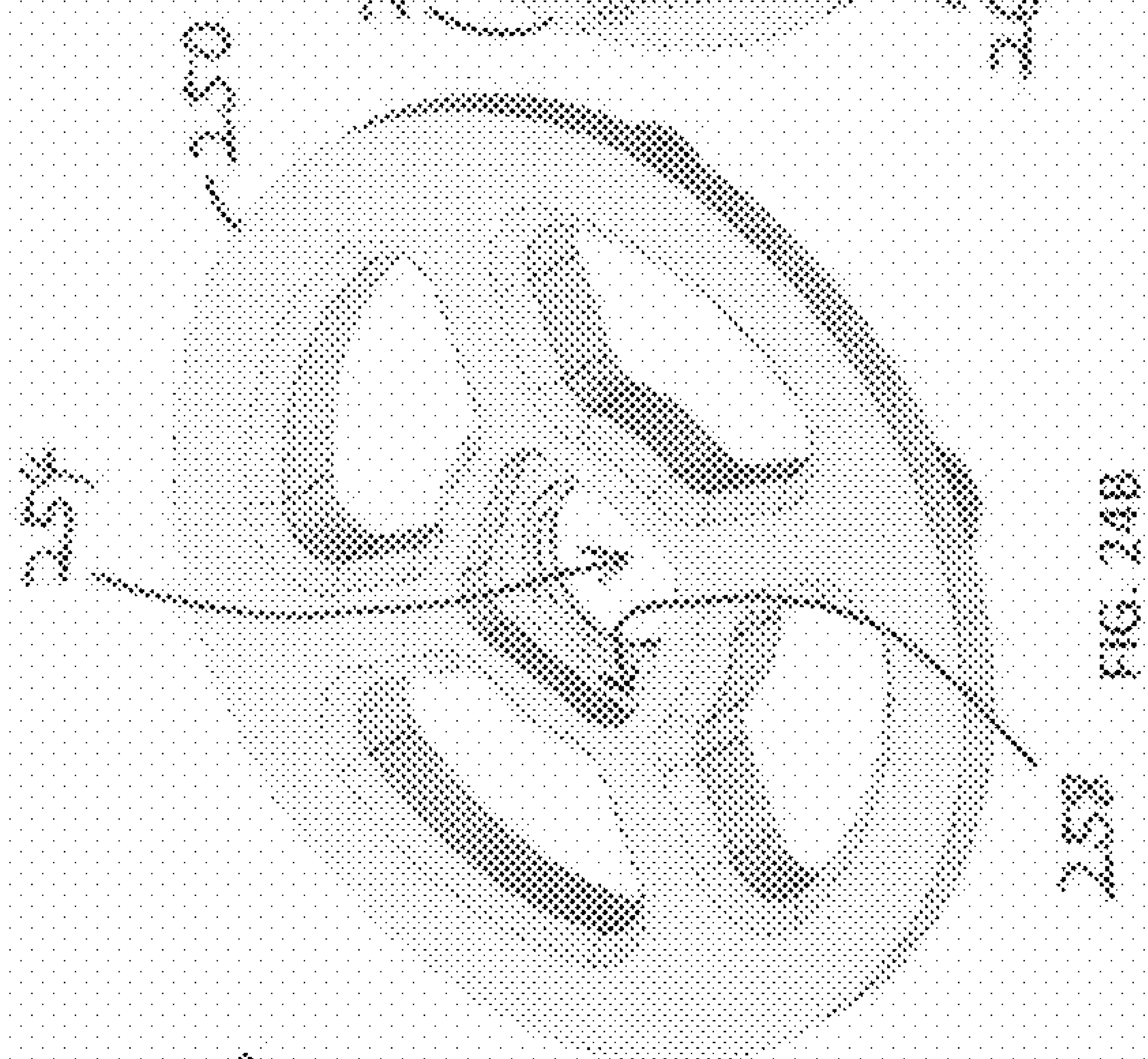

FIG. 24B

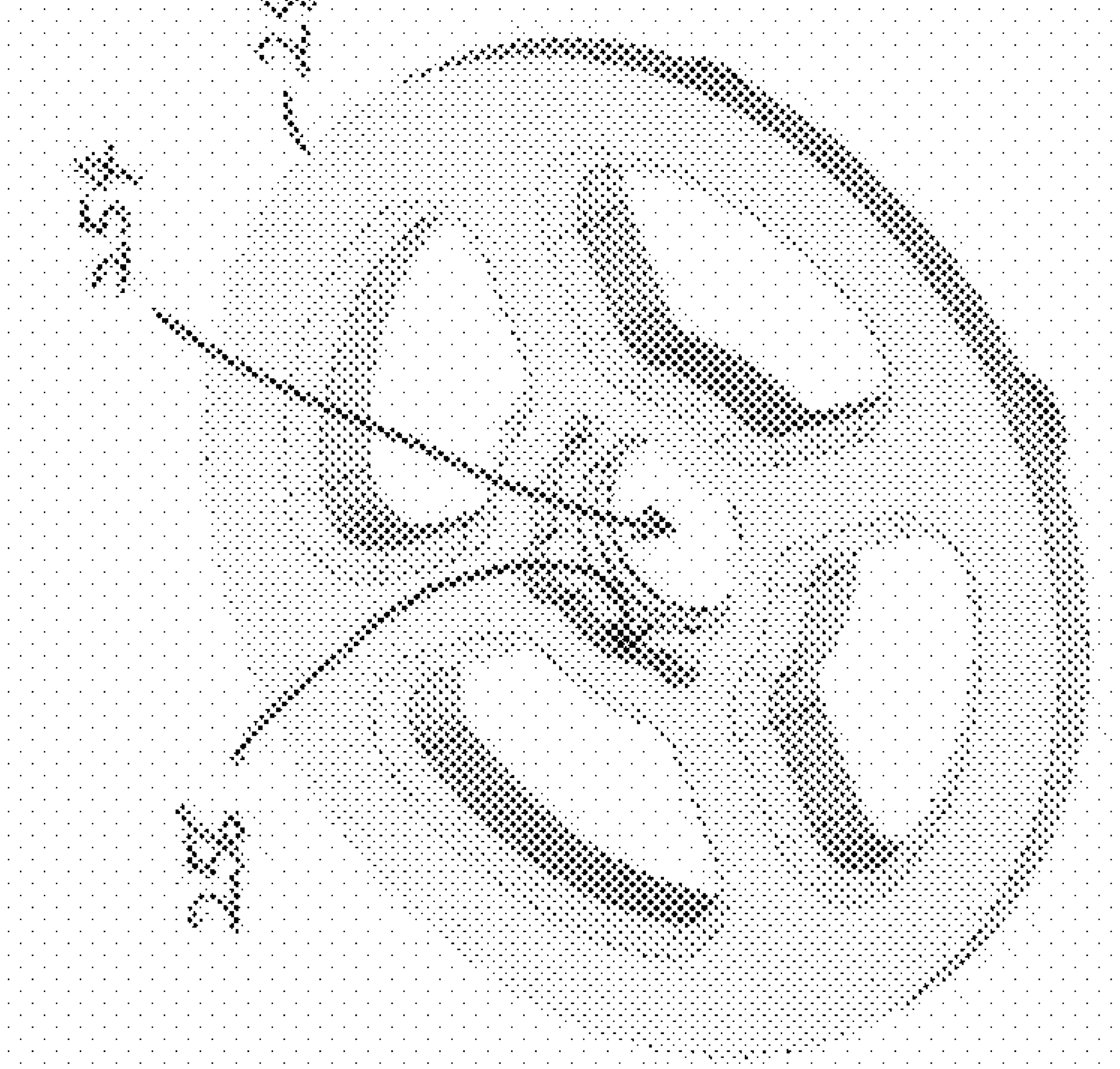

FIG. 24A

HIP ARTHROPLASTY IMPLANTS

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application is a continuation-in-part of U.S. patent application Ser. No. 17/024,876, filed Sep. 18, 2020, which is incorporated herein by reference.

FIELD

The present disclosure generally relates to hip arthroplasty and, in particular, to hip arthroplasty implants.

BACKGROUND

Hip arthroplasty, often called hip replacement, is a surgical procedure used to reconstruct and resurface a hip joint that has been damaged by disease or injury, such as by arthritis or hip fracture. Total hip arthroplasty devices replace both acetabulum and the femoral head which comprise the hip joint, where the femur articulates relative to the acetabulum. To replace the hip joint, hip arthroplasty includes a femoral implant secured to the end of the femur and an acetabular implant secured to the acetabulum that forms a replacement articulating surface which interfaces with the femoral implant. The femoral implant is pivotably coupled to the acetabular implant, thereby reconstructing the hip joint.

SUMMARY

In one aspect of the present disclosure, an acetabular shell insertion tool with an anti-rotation feature is provided. The insertion tool attaches to an acetabular shell including a center hole having an internal threading and an anti-rotation recess disposed around the center hole and having a predetermined shape. The insertion tool includes an outer shaft and an inner shaft disposed within the outer shaft. The outer shaft has an anti-rotation projection shaped to be received in the anti-rotation recess of the acetabular shell so as to prevent rotation of the outer shaft relative to the acetabular shell, thereby preventing the insertion tool from disengaging from the shell. The inner shaft has a threaded tip adapted to be threaded into the internal threading of the center hole to lock the insertion tool to the acetabular shell.

Other objects and features of the present disclosure will be in part apparent and in part pointed out hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective of an acetabular implant according to one embodiment of the present disclosure;

FIG. **2** is a cross section of the acetabular implant;

FIG. **3** is an exploded view of the acetabular implant;

FIG. **4** is a perspective of an acetabular shell of the acetabular implant;

FIG. **5** is a cross section of the acetabular shell;

FIG. **6** is an enlarged cross section of the acetabular shell;

FIG. **7** is a perspective of an acetabular liner of the acetabular implant;

FIG. **8** is a cross section of the acetabular liner;

FIG. **9** is an enlarged cross section of the acetabular liner;

FIG. **10** is a perspective of an acetabular shell according to another embodiment of the present disclosure;

FIG. **11** is a perspective of an acetabular shell according to another embodiment of the present disclosure;

FIG. **12** is a perspective of an acetabular shell according to another embodiment of the present disclosure;

FIG. **13** is a perspective of an acetabular shell according to another embodiment of the present disclosure;

FIG. **14** is a perspective of an acetabular shell according to another embodiment of the present disclosure;

FIG. **15** is a side elevation of shell insertion tool according to one embodiment of the present disclosure;

FIG. **16** is a perspective of an acetabular implant according to another embodiment of the present disclosure;

FIG. **17** is a cross section of the acetabular implant of FIG. **16**; and

FIG. **18** is a cross section of a mobile insert of the acetabular implant of FIG. **16**.

FIGS. **19**A and **19**B are cross-sectional views of a shell insertion tool according to one aspect the present disclosure;

FIGS. **20**A and **20**B illustrate exemplary anti-rotation projections of the shell insertion tool of FIG. **19** according to one aspect the present disclosure;

FIG. **21** is a cross-sectional view of a shell insertion tool according to another aspect the present disclosure;

FIGS. **22**A and **22**B are cross-sectional and perspective views, respectively, of a shell insertion tool according to another aspect the present disclosure;

FIG. **23** is a cross-sectional view of a shell insertion tool that attaches to a rim plate according to one aspect the present disclosure;

FIG. **24**A to **24**C are perspective views of rim plates to which a shell insertion tool attaches according to another aspect the present disclosure.

Grayscale shading in the drawings indicates a portion of a component that was cut by a section plane.

Corresponding reference characters indicate corresponding parts throughout the drawings.

DETAILED DESCRIPTION OF THE DISCLOSURE

Various different systems and methods for carrying out and performing hip arthroplasty are disclosed here. The different systems for hip arthroplasty disclosed herein include implants (e.g., acetabular implants and components thereof) and installation or arthroplasty tools for installing the implants. The different methods for hip arthroplasty disclosed herein include methods for installing acetabular implants.

Referring to FIGS. **1**-**9**, an acetabular implant for hip arthroplasty according to one embodiment of the present disclosure is generally indicated at reference numeral **10**. In the illustrated embodiment, the implant **10** is a fixed-bearing type implant. The implant **10** includes an acetabular shell **12**, an acetabular liner **14** and a femoral head **16**. The femoral head **16** is generally spherical, with a spherical outer surface. The femoral head **16** defines a stem cavity **18** sized and shaped to receive a stem (not shown) of a femoral implant (not shown) to couple the femoral head to the femoral implant. In some embodiment, the femoral head **16** may be considered part of the femoral implant.

Referring to FIGS. **4**-**6**, the shell **12** is configured to be attached to an acetabulum (not shown) of a patient. Specifically, the shell **12** is implanted in the acetabulum of the patient. The shell **12** includes a body (e.g., a generally spherical wall) having an outer surface **20** and an inner surface **22**. The outer and inner surfaces **20**, **22** are generally spherically shaped. The outer surface **20** of the shell **12** is generally semi-spherical. The outer surface **20** may be porous to enable ingrowth of the bone into the shell **12** after the shell is placed in the bone in order to form a strong connection between the shell and the bone. The shell **12** has a proximal end **24** and a distal end **26**. The distal end **26** of the shell is generally located at the apex of the spherical body. The shell **12** includes (or defines) a central axis CA (e.g., a shell central axis) extending between the proximal and distal ends **24**, **26**. The central axis CA generally extends through the apex of the spherical body. The inner surface **22** of the shell **12** defines a shell cavity **28**. The shell cavity **28** is sized and shaped to receive the liner **14**. The inner surface **22** of the shell **12** includes a tapered shell section **22**A, a spherical shell section **22**B and a transition shell section **22**C generally extending between the tapered shell section and the spherical shell section. The tapered shell section **22**A is proximal of the spherical shell section **22**B. The tapered shell section **22**A tapers inward toward the central axis CA of the shell **12** as the tapered shell section extends distally toward the distal end **26**. Thus, the tapered shell section **22**A has a generally truncated cone shape. In the illustrated embodiment, the tapered shell section **22**A extends distally from the proximal end **24**. The tapered shell section **22**A tapers at an angle α (as shown in FIG. **5**) relative to the central axis CA (e.g., a line parallel to the central axis). Preferably, the angle α of the tapered shell section is within the inclusive range of about 10 degrees to about 30 degrees, and more preferably within the inclusive range of about 15 degrees to about 25 degrees, and more preferably about 19 degrees. For example, in one embodiment, the angle α of the tapered shell section **22**A is about 18.8 degrees. The tapered shell section **22**A and transition shell section **22**C extend circumferentially around the central axis CA. The spherical shell section **22**B is generally spherically shaped (e.g., is a partial sphere) with an apex generally aligned with the central axis CA. Other configurations of the shell **12** are within the scope of the present disclosure.

The shell **12** includes (or defines) at least one fastener opening **30**. Each fastener opening **30** is sized and shaped to receive a fastener (not shown), such as a bone screw, to secure the shell **12** to the acetabulum. Each fastener opening **30** is disposed in the spherical shell section **22**B of the inner surface **22**. In the illustrated embodiment, the shell **12** includes three fastener openings **30**. The three fastener openings **30** are in a triangle arrangement, although other arrangements are within the scope of the present disclosure. More or fewer fastener openings **30** are also within the scope of the present disclosure. For example, the shell can include five fastener openings **30**. One embodiment of a shell **112** having five fastener openings **30** is shown in FIG. **10** and another embodiment of a shell **212** having five fastener openings is shown in FIG. **11**. The five fastener openings **30** of shell **112** are arranged in generally an X-shape. The five fastener openings **30** of shell **212** are arranged in generally two circumferential rows stacked on top of each other, with a first row closest to the apex of the spherical shell section **22**B having two fastener openings and a second row furthest from the apex having three fastener opening, radially offset from the two fastener openings in the first row. Other numbers and/or arrangements of the fastener openings are within the scope of the present disclosure. The numerous fastener openings **30** give the surgeon flexibility for the placement of the fastener in the acetabulum.

Referring back to FIG. **4**, the shell **12** includes a tool interlocking structure **32**. The tool interlocking structure **32** is configured to mate with a shell insertion tool **90** (FIG. **15**) to inhibit the shell **12** from rotating relative to the shell insertion tool when the shell and shell insertion tool are coupled together. The shell insertion tool **90** includes threads that mate with threads of the shell **12** (at the apex) to couple the shell and shell insertion tool **90** together. The shell **12** includes a threaded opening **36** disposed at the apex of the spherical shell section **22**B, and, thus, is generally aligned with the central axis CA. The shell insertion tool **90** threads into the threaded opening **36** to couple to the shell **12**. In the illustrated embodiment, the tool interlocking structure **32** includes an insertion tool recess **34**. The insertion tool recess **34** is generally disposed at the apex of the spherical shell section **22**B, and, thus, is generally aligned with the central axis CA. The insertion tool recess **34** is sized and shaped to revive a shell projection **92** of the shell insertion tool **90**. The insertion tool recess **34** includes at least one rotation inhibiting section **34**A (e.g., lobe). In the illustrated embodiment, the insertion tool recess **34** includes four rotation inhibiting sections **34**A, although more or fewer are within the scope of the present disclosure. Each rotation inhibiting section **34**A is sized and shaped to receive a rotation inhibiting structure **92**A (e.g., projection) of the shell insertion tool to inhibit the shell **12** from rotating about the central axis CA when the shell and shell insertion tool **90** are coupled together. Each rotation inhibiting section **34**A is offset from the central axis CA. When the shell insertion tool **90** and the shell **12** are coupled together, the shell projection **92** extends into (e.g., mates or registers with) the insertion tool recess **34** (e.g., each rotation inhibiting structure **92**A extends into one of the rotation inhibiting sections **34**A). The engagement between the shell projection **92** and the shell **12** at the insertion tool recess **34** (e.g., the rotation inhibiting structure **92**A and the shell at the rotation inhibiting section **34**A), prevents the shell from inadvertently rotating (e.g., about the central axis CA) and potentially uncoupling (e.g., unthreading) from the shell insertion tool **90**, especially if the inserter tool has not been threaded into the central threaded hole of the shell **12**.

The insertion tool recess **34** may have generally any shape. In the illustrated embodiment, the insertion tool recess **34** has a generally circular shape with four rotation inhibiting sections **34**A extending radially outward from a circumference of the circle at equally spaced intervals. Other configurations of the tool interlocking structure **32** are within the scope of the present disclosure. For example, the insertion tool recess can have other shapes and sizes. It is understood whatever the shape and size of the insertion tool recess, the shell projection of the shell insertion tool **90** has a corresponding (e.g., confirming, matching) size and shape.

In one example, referring to FIGS. **10** and **11**, an insertion tool recess for a shell **112**, **212** according to another embodiment of the present disclosure is generally indicated at reference numeral **134**. In this embodiment, the insertion tool recess **134** has a generally circular shape with two rotation inhibiting sections **134**A extending radially outward from a circumference of the circle on generally opposite sides thereof.

Referring to FIG. **12**, an insertion tool recess for a shell **312** according to another embodiment of the present disclosure is generally indicated at reference numeral **334**. In this embodiment, the insertion tool recess **334** has a generally polygonal (e.g., rectangular, square, etc.) shape with the corners (e.g., rounded corners) forming the rotation inhibiting sections **334**A. Other polygonal shapes are within the scope of the present disclosure.

Referring to FIG. **13**, an insertion tool recess for a shell **412** according to another embodiment of the present disclosure is generally indicated at reference numeral **434**. In this embodiment, the insertion tool recess **434** has a generally triangular shape, with a generally center circle shaped section and three rotation inhibiting sections **434**A, having generally triangular or trapezoidal shapes extending radially outward from the circle shaped section at equally spaced intervals.

Referring to FIG. **14**, an insertion tool recess for a shell **512** according to another embodiment of the present disclosure is generally indicated at reference numeral **534**. In this embodiment, the insertion tool recess **534** has a generally star shape (e.g., rounded star shape) with the points of the star shape forming the rotation inhibiting sections **534**A. In the illustrated embodiment, the star shape of the insertion tool recess **534** has four points, although more or fewer points are within the scope of the present disclosure.

Referring back to FIGS. **7-9**, the liner **14** of the implant **10** is configured to be attached to the shell **12**. In particular, the liner **14** is sized and shaped to be disposed in the shell cavity **28** of the shell **12** (e.g., the shell cavity is sized and shaped to receive the liner). The liner **14** includes a body (e.g., a generally spherical wall) having an outer surface **38** and an inner surface **40**. The outer and inner surfaces **38**, **40** are generally spherically shaped. The inner surface **40** defines a liner cavity **42**. The liner cavity **42** is sized and shaped to receive at least one of a mobile insert, as described in more detail below, or the femoral head **16**. In the illustrated embodiment, the liner cavity **42** is sized and shaped to receive the femoral head **16**. The inner surface **40** is generally semi-spherical. The inner surface **40** is smooth to permit the mobile insert or femoral head **16** received in the liner cavity **42** to articulate or pivot relative to the liner **14**. Optionally, the inner surface **40** may be polished to a mirror finish, especially if the part is metal. The liner **14** has a proximal end **44** and a distal end **46**. The distal end **46** of the liner **14** is generally located at the apex of the spherical body. The liner **14** includes (e.g., defines) a central axis CA**1** (e.g., a liner central axis) extending between the proximal and distal ends **44**, **46**. The central axis CA**1** generally extends through the apex of the spherical body. When the liner **14** is coupled to the shell **12** (e.g., disposed in the shell cavity **28**) the central axes CA, CA**1** of the liner and shell are generally coextensive with one another.

The outer surface **38** of the liner **14** includes a tapered liner section **38**A, a spherical liner section **38**B and a transition liner section **38**C generally extending between the tapered liner section and the spherical liner section. The tapered liner section **38**A is proximal of the spherical liner section **38**B. The spherical liner section **38**B generally corresponds (e.g., is generally sized and shaped to conform) to the spherical shell section **22**B of the shell **12**. Because a snap-fit receiver **48** (see FIG. **6**) and a snap-fit retainer **50** (see FIG. **9**) form a snap-fit connection between the shell and the liner when the liner is inserted into the shell cavity **28** of the shell, the liner **14** has been designed to have a small clearance between the spherical liner section **38**B and the spherical shell section **22**B. Specifically, the clearance is at least 0.1 mm and at most 0.4 mm in one embodiment. The clearance provides the benefit of less rubbing between the liner **14** and the shell **12** to reduce the possibility of any shaving which could be detrimental to the patient.

The spherical shell section **38**B is generally spherically shaped (e.g., is a partial sphere) with an apex generally aligned with the central axis CA. The transition liner section **38**C generally corresponds (e.g., is generally sized and shaped to conform) to the transition shell section **22**C of the shell **12** such that the transition liner section and the transition shell section generally mate (e.g., engage) when the liner **14** is coupled to the shell. In addition, the tapered liner section **38**A generally corresponds (e.g., is generally sized and shaped to conform) to the tapered shell section **22**A of the shell **12** such that the tapered liner section and the tapered shell section generally mate (e.g., engage) when the liner **14** is coupled to the shell. The tapered liner section **38**A has a taper that corresponds to (e.g., matches) the taper of the tapered shell section **22**A of the shell **12**. The tapered liner section **38**A tapers inward toward the central axis CA**1** of the liner **14** as the tapered liner section extends distally toward the distal end **46**. Thus, the tapered liner section **38**A has a generally truncated cone shape. In the illustrated embodiment, the tapered liner section **38**A extends distally from the proximal end **44**. The tapered liner section **38**A tapers at an angle β (FIG. **8**) relative to the central axis CA**1** (e.g., a line parallel to the central axis). Preferably, the angle β of the tapered shell section is within the inclusive range of about 10 degrees to about 30 degrees, and more preferably within the inclusive range of about 15 degrees to about 25 degrees, and more preferably about 19 degrees. Preferably, the angle β is slightly greater than the angle α of the taper of the tapered shell section **22**A. For example, in one embodiment, the angle β of the tapered liner section **38**A is about 19 degrees. The slightly larger angle β than the angle α ensures the tapered liner section **38**A is received by and engages the tapered shell section **22**A in an interference fit. The tapered liner section **38**A is configured to engage the tapered shell section **22**A to inhibit movement of the liner **14** relative to the shell **12** when the liner is disposed in the shell cavity **28** of the shell. When coupled together, the tapered liner section **38**A and the tapered shell section **22**A engage each other to inhibit the liner **14** from moving relative to the shell **12**. Specifically, the engagement of the tapered liner section **38**A and the tapered shell section **22**A inhibits the liner **14** from rotating, about an axis of rotation perpendicular to the central axes CA, CA**1**, relative to the shell **12**. The tapered liner section **38**A and transition liner section **38**C extend circumferentially around the central axis CA**1**. Other configurations of the liner are within the scope of the present disclosure.

The liner **14** constructed using (e.g., may be made from) any suitable material, such as a plastic, a metal (such as a cobalt-chrome alloy), or a ceramic. In certain applications, such as a dual mobility application (discussed in more detail below), constructing the liner from a ceramic may be preferred because ceramic is harder and smoother than metal, providing a better wear or bearing surface (e.g., inner surface **38** and or inner surface **40**). Ceramic liners are also better at preventing particles from being generated due to micro-motion between the liner **14** and the shell **12**, then metal liners.

Referring to FIGS. **2**, **6** and **9**, the shell **12** and the liner **14** have corresponding connectors that secure the shell and liner together when the liner is disposed in the shell cavity **28** of the shell. In the illustrated embodiment, the shell **12** and liner **14** form a snap-fit connection therebetween to couple and secure the shell and liner together. The shell **12** includes a snap-fit receiver **48** and the liner **14** includes a snap-fit retainer **50** sized and shaped to be received by the snap-fit receiver to form the snap-fit connection between the shell and the liner when the liner is inserted into the shell cavity **28** of the shell. The snap-fit receiver **48** includes a generally circumferential recess **52** and the snap-fit retainer **50** includes a generally circumferential lip **54** (e.g., detent, catch) that is sized and shaped to be received by (e.g., inserted into) the recess. The circumferential recess **52** and the circumferential lip **54** extend circumferentially around the central axes CA, CA**1**. The lip **54** is resiliently deflectable to permit the liner **14** to be inserted into the shell cavity

28 of the shell 12. As the liner 14 is inserted distally into the shell cavity 28 of the shell 12, the shell (e.g., tapered shell section 22A) deflects or deforms the lip 54. Once the lip 54 is aligned with the recess 52, the lip returns or snaps-back to its undeformed state (FIG. 9), extending into the recess and forming the snap-fit connection securing the liner to the shell (FIG. 2). Other configurations of the connectors securing the shell and liner together are within the scope of the present disclosure.

Referring to FIGS. 2, 4, 5, 7 and 9, the shell 12 and the liner 14 may include corresponding interlocking structures to inhibit movement (e.g., rotation) of the shell and liner relative to one another. In the illustrated embodiment, the shell 12 includes at least one shell interlocking structure 56 and the liner 14 includes at least one liner interlocking structure 58. Preferably, the shell 12 includes a plurality of shell interlocking structures 56 and the liner 14 includes a plurality of liner interlocking structures 58. In the illustrated embodiment, the shell 12 includes twelve shell interlocking structures 56 and the liner 14 includes twelve liner interlocking structures 58, although more or fewer shell and liner interlocking structures are within the scope of the present disclosure. For example, the shell can include six shell interlocking structures and the liner can include six liner interlocking structures. The plurality of shell interlocking structures 56 are circumferentially spaced apart from one another (about the central axis CA of the shell 12). Likewise, the plurality of liner interlocking structures 58 are circumferentially spaced apart from one another (about the central axis CA1 of the liner 14). Each shell interlocking structure 56 is configured to mate (e.g., interlock) with one of the liner interlocking structures 58 to inhibit rotation of the liner 14 relative to the shell 12 about the central axes CA, CA1 when the liner is disposed in the shell cavity 28 of the shell. The shell interlocking structure 56 includes an interlocking recess 60 and the liner interlocking structure 58 includes an interlocking projection 62 that is sized and shaped to be received by the interlocking recess. In other words, the interlocking recess 60 and interlocking projection 62 have corresponding (e.g., matching) shapes and sizes. In the illustrated embodiment, the shell interlocking structures 56 are disposed generally adjacent the proximal end 24 of the shell 12. The liner interlocking structures 58 are also disposed generally adjacent the proximal end 44 of the liner 14. When the shell 12 and liner 14 are coupled together, each interlocking projection 62 extends into (e.g., mates, registers or interlocks with) one of the interlocking recesses 60. The engagement between the interlocking projections 62 of the liner 14 and the shell 12 at the interlocking recesses 60, prevents the liner from inadvertently rotating (e.g., about the central axes CA, CA1) relative to the shell.

Referring to FIGS. 16-18, another embodiment of an acetabular implant according to the present disclosure is generally indicated by reference numeral 110. Implant 110 is generally analogous to implant 10 and, thus, unless clearly stated or indicated otherwise, the descriptions herein regarding implant 10 (and elements thereof such as shell 12 and liner 14) also apply to implant 110. In this embodiment, the main difference between implant 10 and implant 110 is that implant 110 is a dual mobility type implant. Accordingly, the implant 110 further includes a mobile insert 180. The mobile insert 180 is disposed between the liner 114 and the femoral head 116 and can articulate (e.g., rotate) relative to both the liner and the femoral head.

The mobile insert 180 is configured to couple to both the liner 114 and the femoral head 116. In particular, the mobile insert 180 is sized and shaped to be disposed (e.g., received) in the liner cavity 142 of the liner 114. In this embodiment, the liner cavity 142 of the liner 114 is sized and shaped to receive the mobile insert 180. The mobile insert 180 includes a body (e.g., a generally spherical wall) having an outer surface 182 and an inner surface 184. The mobile insert 180 has a proximal end 178 and a distal end 176 (at generally the apex of the spherical body) with a central axis CA2 (e.g., a mobile insert central axis) extending therebetween (and through the apex of the spherical body). In the position shown in FIG. 17, the central axis CA2 (see FIG. 18) of the mobile insert 180 is generally coextensive with the central axes CA, CA1 of the shell 612 and the liner 114. The outer and inner surfaces 182, 184 are generally spherically shaped. The outer surface 182 is smooth to permit the mobile insert 180 to articular or pivot relative to the liner 114 (e.g., slide on the inner surface 140 of the liner). The spherical outer surface 182 forms the majority of a sphere. For example, in one embedment, the height (extending between the proximal and distal ends 178, 176) of the mobile insert 180 (e.g., height of the outer surface 182) is within the inclusive range of about 55% to about 75% of an outer diameter of the mobile insert (e.g., diameter of the outer surface), or more preferably within the inclusive range of about 60% to about 70% of the outer diameter, or even more preferably about 65% of the outer diameter. This larger outer surface 182 increases the range of motion between the mobile insert 180 and the liner 114 over conventional mobile inserts that are typically only semi-spherical.

The inner surface 184 of the mobile insert 180 defines a mobile insert cavity 186 sized and shaped to receive the femoral head 116. The inner surface 184 is smooth to permit the mobile insert 180 to articular or pivot relative to the femoral head 116 (e.g., permit the femoral head to slide on the inner surface of the mobile insert). The mobile insert 180 is configured to attach to the femoral head 116 to prevent the mobile insert and femoral head from decoupling from one another. In the illustrated embodiment, the mobile insert 180 is configured to form a snap-fit connection with the femoral head 116. The inner surface 184 has a proximal rim 185. The inner surface 184 generally extends proximally, in a spherical manner, from an apex of the sphere to the proximal rim 185. In the illustrated embodiment, the proximal rim 185 is distal of the proximal end 178. Like the outer surface 182, the inner surface 184 forms the majority of a sphere. For example, in one embedment, the height (between the apex of the spherical inner surface 184 and the proximal rim 185 and extending parallel to the central axis CA2) of the inner surface 183 (e.g., a height of the mobile insert cavity 186) is within the inclusive range of about 55% to about 75% of an inner diameter of the inner surface 184, or more preferably within the inclusive range of about 60% to about 70% of the inner diameter, or even more preferably about 65% of the inner diameter. As a result, a proximal portion of the inner surface 184 generally tapers toward the central axis CA2 as it extends proximally toward the proximal rim 185. This proximal portion of the inner surface 184 retains the femoral head 116 in the mobile cavity 186. Thus, the inner surface 184 surrounds a majority of the spherical femoral head 116 to retain the femoral head in the mobile insert cavity 186. The mobile insert 180 is constructed using a resiliently deflectable material. Accordingly, the mobile insert 180 (e.g., proximal rim 185) is resiliently deflectable to permit the femoral head 116 to inserted into the mobile insert cavity 186. As the femoral head 116 is inserted distally into the mobile insert cavity 186, the mobile insert deflects or deforms (e.g., the proximal rim 185 expands radially outward) to enlarge the proximal end of the mobile insert cavity to permit the femoral head to pass therethrough. Once the femoral head **116** is in the mobile insert cavity **186** (e.g., the widest part of the femoral head has passed the proximal rim **185**), the mobile insert **180** returns or snaps-back to its undeformed state (FIG. **18**), forming the snap-fit connection and securing the femoral head to the mobile insert. In one embodiment, an insertion tool or press (not shown) may be required to insert the femoral head **116** into the mobile insert cavity **186**.

The mobile insert **180** may also include a stem relief recess **188** at a proximal end of the mobile insert cavity **186**. The stem relief recess **188** is configured to receive (intermittently receive as need) a stem (not shown) of the femoral implant when the femoral implant (e.g., femoral head **116**) rotates relative to the mobile insert **180**. This increases the possible range of motion between the femoral implant and the mobile insert **180**. In the illustrated embodiment, the stem relief recess **188** is generally defined by an inner circumferential chamfer (e.g., a tapered inner surface) of the mobile insert **180** extending between the proximal rim **185** and the proximal end **178** of the mobile insert. Other configurations of the mobile insert **180** are within the scope of the present disclosure.

In addition to the mobile insert **180**, the implant **110** has a liner **114** with a different configuration. The liner **114** does not includes a snap-fit retainer, such as snap-fit retainer **50**, to secure the liner to the shell **612**. In this embodiment, the liner **114** is preferably made of a ceramic or metallic alloy such as cobalt chrome alloy, which may be generally unsuitable for forming a snap-fit retainer (e.g., the snap-fit retainer may break instead of resiliently deforming when inserted into the shell **612**). In the illustrated embodiment, the shell **612** still includes a snap-fit receiver **648**, although in other embodiments, the snap-fit receiver may also be eliminated from the shell. In addition, in this embodiment, the liner **114** does not include liner interlocking structures **58**. In the illustrated embodiment, the shell **612** still includes the shell interlocking structures **56**, although in other embodiment, the shell interlocking structures may also be eliminated from the shell. Moreover, in this embodiment, the liner **114** includes an alignment projection **189**. The alignment projection **189** generally extends distally from the apex of the spherical outer surface **138** of the liner **114**. The alignment projection **189** is configured to be inserted into the threaded opening **636** (broadly, an alignment recess) of the shell **612**. It is understood the alignment projection **189** could be configured to extend into a different recess (e.g., opening) of the shell **612**. The insertion of the alignment projection **189** into the alignment recess **612** facilitates the alignment and positioning (e.g., centering) of the liner **114** relative to the shell **612** when the liner is being coupled to the shell.

In operation, to implant an acetabular implant, such as implant **10**, into the acetabulum of a patient, first the surgeon prepares the acetabulum to receive the shell **12** of the implant. Preparing the acetabulum may include one or more of reaming, cutting, and the like to shape the acetabulum to receive the shell **12**. After, the surgeon couples the shell **12** to the shell insertion tool **90**. This may be done by threading the shell **12** onto the threads of the shell insertion tool. Coupling the shell **12** to the shell insertion tool **90** includes inserting the shell projection **92** of the shell insertion tool into the tool interlocking structure **32** (e.g., insertion tool recess **34**) of the shell. The mating of the tool interlocking structure **32** with the shell insertion tool **90** (e.g., shell projection **92**) while the shell and shell insertion tool are coupled together inhibits the rotation (and inadvertent decoupling) of the shell relative to the shell insertion tool, in particular while the shell is being implanted. The surgeon then uses the shell insertion tool **90** to implant the shell **12**. The surgeon generally moves the shell insertion tool **90**, with the shell **12** thereon, distally into the prepared section of the acetabulum. The surgeon may use a hammer (not shown) to contact the shell insertion tool **90** and drive the shell **12** into the acetabulum. After the shell **12** is in position, the surgeon detaches the shell insertion tool **90** from the shell **12**, This requires the disengagement (e.g., removal) of the shell projection **92** from the tool interlocking structure **32** and then unthreading (e.g., rotating) the shell insertion tool **90** from the shell **12**. If desired, the surgeon can then insert one or more fasteners (not shown) through the one or more fastener openings **30** to secure the shell **12** to the acetabulum.

The liner **14** is then inserted into the shell cavity **28** of the shell **12**. The liner **14** is moved distally into the shell cavity **28**. If the liner includes an alignment projection **189**, such as liner **114**, the surgeon aligns the alignment projection with the alignment recess **36**, **136** (e.g., the threaded opening in the illustrated embodiment). As the surgeon moves the liner **114** distally, the alignment projection **189** moves distally into the alignment recess **36**, **136**. Insertion of the liner **14** also includes mating the one or more liner interlocking structures **58** with the one or more shell interlocking structures **56**. The surgeon rotates the liner **14** about the central axis CA**1**, such that the liner interlocking structures **58** align with the shell interlocking structures **56**. As the liner **14** is moved distally, the liner interlocking structures **58** mate with the shell interlocking structures **56**. Specifically, each liner interlocking projection **62** moves into one of the interlocking recesses **60** (through an open proximal side thereof). The mating of the shell and liner interlocking structures **56**, **58** inhibits the rotation, about the central axes CA, CA**1**, of the liner **14** relative to the shell **12**. The mating of the shell and liner interlocking structures **56**, **58** and the alignment projection **189** with the alignment recess **36**, **136** may occur generally simultaneously. Once the surgeon moves the liner **14** fully into the shell cavity **28**, the snap-fit connection will form between liner and the shell to secure the liner in the shell cavity of the shell. The tapered portion **38**A of the liner **14** and tapered portion **22**A of the shell **12** also create an interference fit to secure the liner in the shell. In fact, the interference fit of the tapered portion due to the difference in angles α and β may secure the liner **14** to the shell **12** even without the snap-fit connection. As the surgeon moves the liner **14** into the shell cavity **28**, the lip **54** of the liner is compressed and then expands (e.g., snaps-backs) into the recess **52** of the shell **12**, once they become aligned.

With a fixed-bearing implant, such as implant **10**, after the liner **14** is coupled to the shell **12**, the surgeon then inserts the femoral head **16** (which may already be attached to the stem of the femoral implant) into the liner cavity **42** of the liner. With a dual-mobility implant, such as implant **110**, the surgeon will first attach the mobile insert **180** to the femoral head **116** before inserting the mobile insert (and femoral head) into the liner cavity **142** of the liner **114**. The femoral head **116** may be attached to the stem of the femoral implant after it is coupled to the mobile insert **180**. To attach the mobile insert **180** to the femoral head **116**, the surgeon moves the femoral head distally into the mobile insert cavity **186**. As the femoral head **116** moves into the mobile insert cavity **186**, the femoral head expands the mobile insert **180** (e.g., the proximal end of the mobile insert cavity), which then retracts (e.g., snaps-back) once the femoral head is in the mobile insert cavity. In one embodiment, the surgeon uses a tool or press to couple the mobile insert **180** and the femoral head **116** together. The surgeon then insertions the mobile insert **180**, with the femoral head **116**, into the liner cavity **142** of the liner **114**.

The order of execution or performance of the operations in embodiments of the aspects of the present disclosure described herein are not essential, unless specifically stated or indicated otherwise. That is, the operations may be performed in any order and/or simultaneously, and the embodiments of the aspects of the disclosure may include additional or fewer operations than those disclosed herein. For example, it is contemplated that executing or performing a particular operation before, contemporaneously with, or after another operation is within the scope of the present disclosure.

As is apparent, the implants **10**, **110** and elements thereof disclosed herein are generally analogous to one another and, thus, for ease of comprehension, where similar, analogous or identical parts are used between the various different implants (or elements thereof), reference numerals having the same last two digits are employed (and the same subsequent letter, if applicable). For example, shell **12** is analogous to shells **112**, **212**, **312**, **412**, **512**, and **612** and, thus, all these shells have the same last two digits of "12." Thus, unless clearly stated otherwise, the above descriptions regarding the implants and elements thereof apply equally to all the analogous implants and the elements thereof. For example, at least some of the description related to insertion tool recess **34** may also apply to insertion tool recess **134** and/or vice versa. In another example, at least some of the description related to the inner surface **22** of shell **12** (e.g., the tapered shell section **22**A, the spherical shell section **22**B and the transition shell section **22**C) applies equally to shells **112**, **212**, **312**, **412**, **512**, **612**.

For the materials of each component of dual-mobility application such as one shown in FIG. **17**, in one embodiment, the acetabular shell **12** may be made of metal such as a Titanium alloy, liner **14** may be made of either ceramic material or metal such as a cobalt-chrome alloy. For ceramic materials, a preferred material may be Aluminum oxide (Al_2O_3). Ceramic material for the liner **14** may be preferred if the fit between the liner and the shell **12** is less than perfect which allows the two materials to rub together. Metal to metal rubbing from micro motion may cause metallic shavings or particles to be dislodged. The mobile insert **180** may be made of polyethylene material such as a compression-molded, GUR **1020**E material. The femoral head **160** may be made of metal such as a cobalt-chrome alloy or ceramic material Aluminum oxide (Al_2O_3) material.

FIGS. **19**A through **24**C disclose an impaction tool system for seating an acetabular shell in the acetabular space. When seating the acetabular shell with a conventional impaction tool whose tip is threaded into the central hole **36**, there is a possibility that a user may accidentally disengage the tool while orienting the shell in the acetabular space. Thus, it would be desirable to provide an impaction tool that prevents the user from unthreading and disengaging the tool from the shell.

FIGS. **19**A and **19**B illustrate a shell insertion tool **200** with anti-rotation control according to an embodiment of the present disclosure. The tool **200** has a hollow outer shaft **202** and an internal shaft **204** disposed within the outer shaft. The outer shaft **202** includes a distal sleeve **208**, an impactor sleeve **206** extending proximally from a proximal end of the distal sleeve **208**. The impactor sleeve **206** includes an impactor head **210**. In the embodiment shown, the outer shaft **202** is a single integral piece which is formed from a single metal piece. In other embodiments, the distal sleeve **208** and the impactor sleeve **206** of the outer shaft **202** may be made from two separate pieces that are attached together such as by welding. The impactor sleeve **206** has an internal flat stop **212** which engages a corresponding stop **214** of the internal shaft **204**.

A distal end of the outer shaft **202** as shown in FIGS. **20**A and **20**B has an anti-rotation projection feature **216**,**218** in the shape which is complementary to the anti-rotation recess **34**, **134**, **334** of the acetabular shell **12**. For example, FIG. **20**A has a round projection **216** and four uniformly spaced semi-circular projections extending laterally from the round projection. The projection **216** of FIG. **20**A is configured to be received in the complimentary anti-rotation recess **34** of the acetabular shell **12** as shown in FIG. **4** while the square shaped projection **218** of FIG. **20**B is configured to be received in the complimentary anti-rotation recess **334** of the acetabular shell **312** as shown in FIG. **12**.

A distal end portion **219** of the internal shaft **204** has an external threading configured to be threaded into internal threading of the central hole **36**, as shown for example in FIG. **5**. A proximal end portion of the internal shaft **204** has a key feature such as a hex key configured to receive a hex driver for threading the internal shaft **204** into the acetabular shell **12**.

This anti-rotation feature of the present design provides rotational stability and is concentric or centered with the threaded central hole of the shell. The new shell inserter instruments can mate with the shell's rotational control feature and thread into the apical/central hole of the shell for insertion and impaction of the acetabular shell. Ultimately, the rotational control feature allows a fully seated positioning of the shell without the potential of unthreading the inserter from the shell.

FIG. **21** illustrates an insertion tool **220** according to another embodiment of the present invention. Unlike the insertion tool **220** of FIG. **19**A, the impactor head **210** is part of the internal shaft **222**. An annular stop **214** of the internal shaft **222** and a flat stop **212** of the outer shaft **208** captures an internal spring **226** to provide a constant bias of an opposing force at all times. At rest, the insertion tool **220** is in an unthreaded position. The internal shaft **222** is captured in the outer shaft **208** by a pin **234** in an annular recess defined by a stop **230** and **232**. The pin **234** is permanently attached to the impactor sleeve **224** by welding, for example. The distal end portion of the internal shaft **222** and outer shaft **208** are the same as those of FIGS. **19**A-**19**B and FIGS. **20**A-**20**B.

FIGS. **22**A and **22**B illustrate an insertion tool **238** according to another embodiment of the present invention. Unlike the other insertion tools, the insertion tool **238** is made of a single shaft **240** with an integrated impaction head **242**. The shaft **240** includes a distal end portion comprising a distal projection **244** having a lower outer surface designed to sit flush against the surface of the recess **34** without any rotation control and a threaded tip **246** extending distally of the distal projection **244**. When the threaded tip **246** is threaded into the threaded central hole **36**, the distal projection **244** does not engage the key feature of the recess **34** so that the insertion tool **238** may rotate relative to the acetabular shell **12** about the longitudinal axis of the central hole **36** with perhaps some resistance.

FIG. **23** is a cross-sectional view of a shell insertion tool **200** that attaches to a rim plate according to one aspect of the present disclosure. The use of the rim plate is intended to be an optional secondary step after the initial impaction of the shell **12** into the acetabulum. This rim plate method of impaction allows a greater contact surface area in which the force of impaction spreads out uniformly across the shell's exterior surface. This helps ensures proper seating of the shell **12** into the acetabulum. Although the rim plate impaction method is intended to be an optional secondary step, it may be a primary step without the initial impaction of the shell **12** with the tool **200** locked into the central opening **36** of the shell **12**.

The insertion tool **200** of FIG. **23** is identical to that of FIG. **19**A, except that it attaches to a rim plate as shown in FIGS. **24**A-**24**C. The rim plates are designed to fit over an upper surface of the acetabular shell. Similar to the acetabular shell, a rim plate **248** of FIG. **24**A has a center hole **254** having an internal threading and an anti-rotation recess **256**. Similar to the recess of FIG. **20**A, the recess **256** has a round projection and four uniformly spaced semi-circular projections extending laterally from the round projection. A rim plate **250** of FIG. **24**B has an anti-rotation recess **258** which is square shaped. FIG. **24**C is a bottom perspective view of the rim plate **248** of FIG. **24**A. Similar to the liner **14** of FIG. **7**, the rim plate **248** has uniformly spaced interlocking tabs **260** that rests on corresponding interlocking recesses **60** of the shell **12**. In the embodiment shown, there are six tabs **260** that rest on six of the twelve recesses **60** of the shell **12**.

Although only the insertion tool **200** is shown in conjunction with the rim plates, any of the insertion tools disclosed herein may be used with any of the rim plates.

All insertion tools as disclosed herein may be provided as part of a complete tool kit.

It is apparent and understood that the elements, features, and/or teachings set forth in each embodiment disclosed herein are not limited to the specific embodiment(s) the elements, features, and/or teachings are described in. Accordingly, it is apparent and understood that the elements, features, and/or teachings described in one embodiment may be applied to one or more of the other embodiments disclosed herein. For example, it is understood that any of the shells disclosed herein may have fastener opening **30** arrangement of shell **12**.

Modifications and variations of the disclosed embodiments are possible without departing from the scope of the disclosure defined in the appended claims.

When introducing elements of the present disclosure or the embodiment(s) thereof, the articles "a", "an", "the" and "said" are intended to mean that there are one or more of the elements. The terms "comprising", "including" and "having" are intended to be inclusive and mean that there may be additional elements other than the listed elements.

As various changes could be made in the above constructions, products, and methods without departing from the scope of the disclosure, it is intended that all matter contained in the above description and shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. An acetabular shell insertion system comprising:
an acetabular shell including:
a center hole having an internal threading;
an anti-rotation recess disposed around the center hole and having a predetermined shape;
an insertion tool including:
an outer shaft having an anti-rotation projection shaped to be received in the anti-rotation recess having the predetermined shape so as to prevent rotation of the outer shaft relative to the acetabular shell;
an inner shaft disposed in the outer shaft and having a threaded tip adapted to be threaded into the internal threading of the center hole to lock the insertion tool to the acetabular shell; and
a rim plate adapted to rest on the acetabular shell and having a threaded center hole adapted to threadably receive the threaded tip of the insertion tool.

2. The system of claim **1**, wherein the anti-rotation recess includes a round recess and a plurality of uniformly spaced cavities extending radially from a central axis of the center hole.

3. The system of claim **1**, wherein the anti-rotation recess includes a square-shaped recess.

4. The system of claim **1**, further comprising a spring disposed between the outer shaft and the inner shaft to provide a bias to urge the inner shaft proximally away from the center hole of the acetabular shell.

5. The system of claim **4**, wherein:
the outer shaft includes a stop disposed around the inner shaft;
the inner shaft includes an annular stop disposed inside the outer shaft, the outer shaft stop and the annular stop defining a channel within which the spring is disposed.

6. The system of claim **5**, wherein the inner shaft includes an impaction head at its proximal end.

7. The system of claim **1**, wherein:
rim plate includes a plurality of anti-rotation tabs;
the acetabular shell includes a plurality of anti-rotation recesses that mate with corresponding anti-rotation tabs of the rim plate.

8. The system of claim **1**, further comprising a second insertion tool having a single shaft, the single shaft having a threaded tip lacking an anti-rotation projection and adapted to be threaded into the internal threading of the center hole to lock the insertion tool to the acetabular shell, the single shaft further having at its proximal end an impaction head.

9. An acetabular shell insertion tool kit comprising:
an insertion tool for attaching to an acetabular shell including a center hole having an internal threading and an anti-rotation recess disposed around the center hole and having a predetermined shape, the insertion tool including:
an outer shaft having an anti-rotation projection shaped to be received in the anti-rotation recess having the predetermined shape so as to prevent rotation of the outer shaft relative to the acetabular shell;
an inner shaft disposed in the outer shaft and having a threaded tip adapted to be threaded into the internal threading of the center hole to lock the insertion tool to the acetabular shell; and
a rim plate adapted to rest on the acetabular shell and having a threaded center hole adapted to threadably receive the threaded tip of the insertion tool.

10. The kit of claim **9**, wherein the anti-rotation projection includes a round projection and a plurality of uniformly spaced extensions extending radially from a longitudinal axis of the outer shaft.

11. The kit of claim **9**, wherein the anti-rotation projection includes a square-shaped projection.

12. The kit of claim **9**, wherein the rim plate includes a round recess disposed around the center hole of the rim plate and a plurality of uniformly spaced cavities extending radially from a central axis of the center hole of the rim plate.

13. The kit of claim **9**, further comprising a spring disposed between the outer shaft and the inner shaft to provide a bias to urge the inner shaft proximally away from the center hole of the acetabular shell.

14. The kit of claim **13**, wherein:

the outer shaft includes a stop disposed around the inner shaft;

the inner shaft includes an annular stop disposed inside the outer shaft, the outer shaft stop and the annular stop defining a channel within which the spring is disposed.

15. The kit of claim **14**, wherein the inner shaft includes an impaction head at its proximal end.

16. The kit of claim **9**, wherein:

rim plate includes a plurality of anti-rotation tabs that mate with corresponding anti-rotation recesses of the acetabular shell.

17. The kit of claim **9**, further comprising a second insertion tool having a single shaft, the single shaft having a threaded tip lacking an anti-rotation projection and adapted to be threaded into the internal threading of the center hole to lock the insertion tool to the acetabular shell, the single shaft further having at its proximal end an impaction head.

18. The kit of claim **9**, wherein the rim plate further includes an anti-rotation cavity having the same shape and size as the anti-rotation recess so as to receive the same anti-rotation projection of the insertion tool.

19. The kit of claim **18**, wherein the rim plate includes a round recess disposed around the center hole of the rim plate and a plurality of uniformly spaced cavities extending radially from a central axis of the center hole of the rim plate.

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